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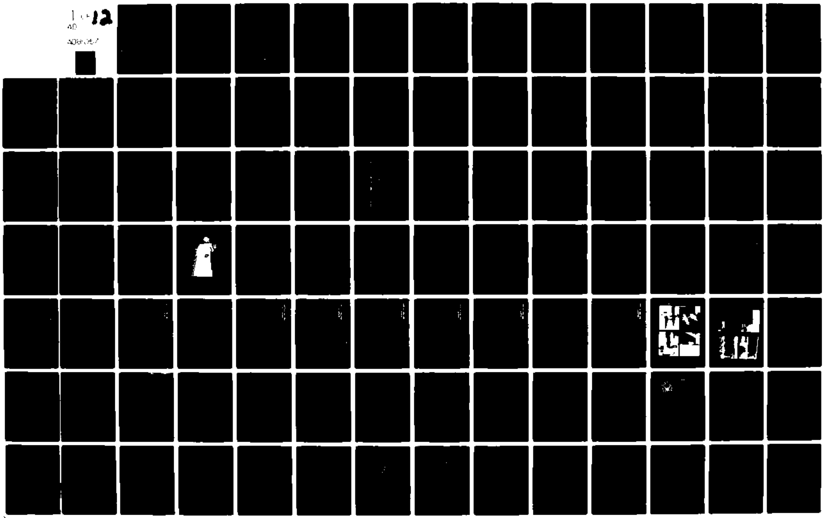

LEVEL III

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REPORT TO THE CONGRESS

FAMILY HOUSING METERING TEST

A TEST PROGRAM TO DETERMINE THE FEASIBILITY OF INSTALLING UTILITY METERS IN MILITARY FAMILY HOUSING, DEVELOPING ENERGY CEILINGS, AND OPERATING A PENALTY BILLING SYSTEM FOR OCCUPANTS WHO OVERCONSUME ENERGY

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APPENDICES

Prepared by the Office of the Deputy Assistant Secretary of Defense (Installations and Housing)

1 March 1980

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DISCLAIMER NOTICE

REPORT TO THE CONGRESS .

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FAMILY HOUSING METERING TEST.

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Volume II.

APPENDICES.

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Prepared by the Office of the Deputy Assistant Secretary of Defense (Installations and Housing)

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APPENDICES

FEASIBILITY STUDY

OF

UTILITY METERING

FOR

FAMILY HOUSING UNITS

AT

PUBLIC WORKS CENTER

GREAT LAKES, ILLINOIS

OCTOBER 1977

Prepared For

Department of the Navy
Northern Division
Naval Facilities Engineering Command
Philadelphia, Pennsylvania 19112

Prepared By

Buchanan, Bellows and Associates, Ltd.
Consulting Mechanical and Electrical Engineers
1509 North Clinton Blvd.
Bloomington, Illinois 61701
Phone: 309-829-9458

Contract No. N62472-77-C-1409 Amendment "C"
BBA Project No. 688.02

Table of Contents

C. #N62472-77-C-1409 "C"
BBA 688.02

FORWARD

This report includes a brief description of the work required at each unit or unit type, freehand sketches as necessary to amplify and/or discribe the work, statements covering the impact of the work on housing residents, cost estimates and recommended alternatives if the cost to isolate and meter certain apartments appears prohibitive.

Cost estimates are broken down by apartment type and by system (i.e., gas, electric, domestic hot water, heating) within each unit type.

Cost estimates are intended to include all work required to isolate services to each apartment and are projected to a construction contract award date of 1 March 1978.

Some discrepancies may appear between final contracts and these cost estimates because of certain necessary assumptions required because of time and because no construction was exposed to examine work concealed within walls, etc.

Another reason for possible discrepancies will be the possible variations in overhead, profit, allowances for unusual work schedules, annoyance factor of obtaining entry access to work areas and coordination of trades, base personnel and residents.

Assumptions: Certain assumptions were made during the field investigation necessary because of time and economics.

1. Apartments for similar units were assumed to be identical. WHAT DID SITE INVESTIGATION SH
2. Similar units were assumed to be identical.
3. Buried utilities were assumed to run in straight lines between points where they surfaced.
4. No upgrading of existing conditions or correcting code violations are included.
5. All work is to be performed as a single contract.
6. Reliance on plant and information provided us by PWC and Base Engineering as correct as regards concealed work.
7. All metering at each unit to be grouped in one or at most two locations.
8. The contractor will be responsible for all utility outages, coordination and relighting of all pilot lights after outages.

Definition of Terms used in this Project:

Apartment: A subdivision of a unit into separate dwelling occupancies regardless of number of levels, bedrooms or layout. Each apartment to have its' utilities metered separately.

Garage: A division of a unit intended to house an automobile. (Some were used for storage but this was not considered a factor.)

Meter: Devices or combination of devices required to count units of energy, providing a direct readout capable of being read visually for purposes of monitoring total energy used by each apartment.

Unit: A separate building consisting of one or more apartments. (See definition of apartment.)

Storage Unit: Structures, usually quite small, separate from the apartments but intended for occupants to use for storage of personal items.

Down Time: Total time estimated to accomplish work at each apartment. Not necessarily consecutive but cumulative.

COST ESTIMATE

1. <u>Forrestal Village (Wherry Apartments)</u>

   15 units - 14 apartments each unit

   Buildings numbered 2913, 2914, 2921, 2925, 2927, 2936, 2937, 2940, 2944, 2945, 2950, 3028, 3030, 3040 and 3042.

   Electrical metering $260,700

   Gas metering (domestic hot water work included) $366,000

2. <u>Forrestal Village (1st Increment MCON)</u>

   a. 7 - 2 apartment units

   Buildings numbered 2135, 2137, 3672, 3678, 3684, 3689 and 3695.

   b. 19 - 4 apartment units

   Buildings numbered 3670, 3671, 3674 through 3677, 3680 through 3682, 3685 through 3688, 3690 through 3692, 3694, 3696 and 3697.

   Electrical metering - a. 7,700
   b. 45,600 $53,300

   Gas metering (includes domestic hot water)
   a. 5,600
   b. 28,500 $34,100

3. <u>Forrestal Village (2nd Increment MCON)</u>

   a. 23 - 4 apartment units

   Buildings numbered 3698 through 3702, 3704, 3706, 3707, 3708, 3711 through 3716, 3718, 3720, 3721, 3723, 3724, and 3726 through 3728.

   b. 8 - 6 apartment units

   Buildings numbered 3703, 3705, 3709, 3710, 3717, 3719, 3722 and 3725.

   Electrical metering - a. 64,400
   b. 31,200 $95,600

   Gas metering (includes domestic hot water)
   a. 172,500
   b. 88,000 $260,500

   Condensate/ BTU metering
   a. 202,400
   b. 105,600 $308,000

4. Nimitz Village (2nd Increment MCON)

5 - 4 apartment units

Buildings numbered 4064 through 4068.

Electrical metering	$14,000
Gas metering (includes domestic hot water work)	$37,500
BTU/Condensate metering	$52,000

5. Nimitz Village (1st Increment Turn Key)

a. 21 - 2 apartment units

Buildings numbered 4104, 4106, 4108, 4110, 4114, 4116, 4119, 4124, 4125, 4128, 4130, 4134 through 4139, 4143, 4145, 4148 and 4149.

b. 12 - 3 apartment units

Buildings numbered 4101, 4107, 4109, 4111, 4113, 4117, 4118, 4122, 4129, 4140, 4142 and 4147.

c. 12 - 4 apartment units

Buildings numbered 4102, 4103, 4105, 4112, 4120, 4121, 4126, 4132, 4133, 4141, 4144 and 4146.

d. 4 - 6 apartment units

Buildings numbered 4115, 4123, 4127 and 4131.

Electrical metering - a. b. c. d.		$63,750
Gas metering		
	a. 16,800	
	b. 14,400	
	c. 21,600	
	d. 12,000	$64,800

6. Hospital

a. 1 - 2 apartment; building number 207H

b. 4 - 2 apartment units

Buildings numbered 205H, 206H, 208H and 209H.

c. 1 - 4 apartment; building number 204H

Electrical metering -	a.	1,840	
	b.	4,360	
	c.	5,040	$11,240
Gas metering	a.	2,000	
	b.	8,000	
	c.	2,000	$12,000
Condensate/BTU metering			
	a.	4,800	
	b.	19,200	
	c.	15,600	$39,600

7. Main Side (Foss Acres)

a. 1 - 3 apartment unit building number 67Q

b. 1 - 4 apartment unit building number 65Q

c. 1 - 6 apartment unit building number 66Q

Electrical metering -	a.	13,570	
	b.	16,100	
	c.	22,000	$51,670
Gas metering	a.	4,100	
	b.	8,100	
	c.	5,200	$17,400
Condensate/BTU metering			
	a.	10,500	
	b.	14,000	
	c.	21,000	$45,500

8. Main Side (Downes Acres)

a. 1 - 7 apartment unit building number 143

b. 1 - 8 apartment unit building number 142

Electrical metering -	a.	15,000	
	b.	14,800	$29,800
Gas metering	a.	12,000	
	b.	14,000	$26,000
Condensate/BTU metering			
	a.	19,200	
	b.	16,800	$36,000

9. <u>Forrestal Village (Garages)</u>

   a. 14 - 6 stall garages

      Buildings numbered 2257, 2350, 2382, 2393, 2448, 2449, 2483, 2484, 2639, 2648, 2681, 2850, 2946, and 2948.

   b. 18 - 8 stall garages

      Buildings numbered 2229, 2325, 2326, 2362, 2363, 2418, 2419, 2454, 2455, 2468, 2470, 2618, 2619, 2654, 2655, 2824, 2915 and 2916.

   c. 2 - 10 stall garages

      Buildings numbered 2929 and 2931.

   d. 2 - 16 stall garages

      Buildings numbered 3034 and 3036.

Electrical metering -	a.	35,000	
	b.	63,000	
	c.	8,900	
	d.	16,200	$123,100
Gas, condensate and/or BTU metering			
	a.	None	
	b.	None	
	c.	None	
	d.	None	None

10. <u>Hospital Garages</u>

   a. 1 - 3 stall garage building number 10H

   b. 1 - 5 stall garage building number 59H

Electrical metering -	a.	1,200	
	b.	2,100	$ 3,300

Gas, condensate and/or BTU metering
a. None
b. None — None

11. <u>Main Side (~~Downes~~ Foss Acres) Garages</u>

a. 1 - 3 stall garage building number 67

b. 1 - 8 stall garage building number 65

See Main Side Downes Acres housing garages are included in that work as they are attached.

12. <u>Forrestal Village (Storage Building)</u>

a. 36 - 4 apartment buildings

b. 8 - 8 apartment buildings

Electrical metering - a. 57,000
b. 25,600 — $82,600

Gas, condensate and/or BTU metering
a. None
b. None — None

Total Electrical Metering	$789,060
Total Gas Metering	$818,300
Total BTU/Condensate Metering	$481,100
Total all Metering for Units Listed	$2,088,460

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SUMMARY OF RECOMMENDATIONS

This is a summary of recommendations presented or implied in the following support data.

1. Forrestal Village (Wherry Apartments)

    a. Increase electrical service size when installing metering.
    b. Proceed with electrical metering.
    c. Provide the gas meters to meter each furnace and cooking range if felt necessary.
    d. DO NOT install new individual gas fired water heaters. Retain central DHW service.
    e. DO NOT run gas piping to dryers and if d. above is followed, HW would not be piped to the washers from each apartment.

2. Forrestal Village (1st Increment MCON)

    a. Meter electrical services.
    b. Meter gas services.

3. Forrestal Village (2nd Increment MCON)

    a. Meter electrical services.
    b. Meter heating services.
    c. DO NOT meter gas services because of high cost to rework gas piping, install new gas water heaters. Also because of serious inconvenience to tenants - messy cutting, patching of roof, walls, floors. Bad.

4. Nimitz Village (2nd Increment MCON)

    a. Meter electrical services.
    b. DO NOT meter gas services because of high costs per unit, serious inconvenience to tenants, messy work, cutting roofs, etc. If metering is decided on, this would imply installing the hot water heaters in each apartment which has serious ramifications space-wise and construction-wise.
    c. Meter the heating services if it is felt the high cost per apartment is justifiable to achieve the end result. I recommend it not be metered, solely because of cost.

5. Nimitz Village (1st Increment Turn Key)

    a. Meter electrical services.
    b. Meter gas services.

6. Hospital

   a. Meter electrical services.
   b. Meter the gas services, however, do not install individual domestic hot water heaters in each apartment because of high cost, serious impact on tenants, especially space-wise.
   c. DO NOT meter heating. High cost and messy reworking of piping. Pipes are old, could cause a great deal of replacement work. Recommend system be left alone. Be grateful all is working well.

7. Main Side (Foss Acres)

   a. Because of the high cost, difficult working conditions, serious impact to tenants, small number of apartments (13), age of buildings and recent rehabilitation work just completed and relatively small apartments, we recommend not doing any metering of any services.

8. Main Side (Downes Acres)

   a. Because of the high cost, difficult working conditions, serious impact to tenants, small number of apartments (15), age of buildings and recent rehabilitation work just completed and relatively small apartments, we recommend not doing any metering of any services.

9. Forrestal Village (Garages)

10. Hospital (Garages)

11. Main Side (Downes Acres - Garages)

12. Forrestal Village (Storage Buildings)

We recommend that none of the above garages and storage units be metered because of the ridiculously high cost to accomplish metering on a per garage or storage unit basis, especially when you consider the demand of one light bulb and one receptacle.

No use of the receptacles was observed and in very few cases were lights (one 60 watt or 40 watt light bulb) observed to be on.

Absolutely DO NOT meter garages or storage units.

SUPPORTING DATA AND ANALYSIS

The following information is support data for each of the lump sum cost estimates given in the preceding cost estimate recap.

Certain recommendations are presented that, if followed, will reduce the cost of the work required to meter utilities because of either consolidating metering or by eliminating it altogether.

The narratives are brief. Sketches that apply to other units or similar units have been referred to and are not repeated for each case.

The order of support data presentation which has been followed in general was to present the area of housing involved with a brief description of the existing facility.

Then proposed solutions to the metering and domestic hot water revisions are presented by brief descriptions with reference to Drawings.

A statement as to obvious inconveniences to residents is presented next.

A recap of total cost estimates is given for convenience.

The narratives are followed by rough cost estimate breakdowns, sketches of proposed solutions where appropriate, and finally by copies of photographs of the areas important to the metering locations and special problem areas. (It is regrettable the color photographs did not reproduce more clearly.)

FORRESTAL VILLAGE
WHERRY APARTMENTS

15 units - 14 apartments per unit

Buildings numbered 2913, 2194, 2921, 2925, 2927, 2936, 2937, 2940, 2944, 2945, 2950, 3028, 3030, 3040 and 3042.

Buildings number 2945 and 3040 were investigated.

2945 - A-F and I-P

Mixture of 2 and 3 bedroom apartments.

One utility room for apartments A-F with water heaters and laundry room.

One utility room for apartments I-P similar to A-F utility room and a laundry room.

Electric service feeds house panels and apartment panels, storage units and yard lights.

Gas service feeds a furnace, hot water heater, range, and unit heater.

See Drawings 2945; E-1A and B and E-2A and B for existing electrical conditions and proposed solution. See photographs.

See Drawings 3040 - 3a and 3b for gas metering and piping solution. See photographs.

Proposed Solutions

Electrtical: For electrical, see Drawings.

Install new meter stack and new apartment main panels together with new feeders, etc. for each apartment. Provide new house panel and meter.

Intercept existing electrical service. Install new meter on exterior wall and extend to new panels - sub feed existing panels.

We recommend increasing main service size to building when this work is done.

This not within scope

Gas:

Gas metering and piping work.

The existing gas meter is located on the outside of the utility room. Since there is no room to mount the individual meters above the existing gas meter, they could be mounted on the inside of the utility room. (See diagram sheet 3040-3b) If a remote readout is required to read meters from outside, it will mean an additional $100.00 per apartment.

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In order to add water heaters to each apartment, a closet will need to be constructed behind each furnace (see sheet 3040-3a) with a door opening into the bedroom. The flue and gas shall tie in to the flue and gas line of the existing furnace.

Provide gas piping to the dryers and unit heater in the central laundry room on the second floor.

However, to feed hot water to each washer will require separate hot water lines from each apartment to each washer. These hot water lines must be installed through a new chase (insulated outdoors) to the laundry room from the apartments.

Separating the gas services to the dryers is reasonable. However, running separate hot water lines from each apartment seems unreasonable considering the amount of energy involved. We recommend the central hot water heater be used to supply these washers.

Additional money could be saved by leaving out the individual water heaters and allowing the central hot water system to remain. Gas to this heater could be metered (by subtraction of other readings) to determine energy used. By comparing this to other similar units a "norm" could be established and when exceeded tenants could be warned they may be penalized.

Gas heating and cooking would be metered.

Impact to Tenants

Electrical: We estimate the facility would be without electrical service for as long as seven days. Perhaps temporary services could be run to each apartment. However, we did not perceive of any simple inexpensive way of doing it.

There is little, if any, work required inside the apartments. All of the work is confined to the utility and laundry rooms or outside.

Cutting and patching of utility room wall will be required.

Gas: If separate water heaters are required in each apartment, then workmen will be in the apartments for at least a week. However, the tenants, though inconvenienced, could remain in the apartments. Some cutting, patching and painting will be required in each apartment. The building would be without gas service for at least 72 hours while the piping changes were completed and meters installed.

Cost Estimates:

Electrical Work $6,830 + 10,550 = $17,380/unit	
Total = 15 x 17, 380 =	$260,700
Gas Work	$366,000
(includes remote read meter)	

FORRESTAL VILLAGE
1ST INCREMENT MCON

a. 7 units - 2 apartments per unit

Buildings numbered 2135, 2137, 3672, 3678, 3684, 3689 and 3695.

Buildings number 3689 and 3695 were investigated.

b. 19 units - 4 apartments per unit

Buildings numbered 3670, 3671, 3674 through 3677, 3680 through 3682, 3685 through 3688, 3690 through 3692, 3694, 3696 and 3697.

Buildings number 3687 and 3697 were investigated.

One type of unit consists of 4 bedroom apartments while the other type were 3 bedroom apartments.

The buildings each had a single gas meter. Each apartment had its own utility room with a gas furnace, dryer, range, and water heater. Also, each apartment had its own electrical panel.

Please refer to drawings 3687 - E-1, 3695 - E-1, 3689-3, 3687-3, 3695-3, and also refer to the attached photographs of these facilities.

Proposed Solutions

Electrical: Refer to the Drawings.

Intercept existing electrical service, install new meters, as required, on exterior of the building and extend new feeders to existing apartment panels.

Gas: Rework existing gas meter on load side of existing gas meter. Install new gas meters. Disconnect gas ranges in common walls and refeed one from new meter location. New meters are to be installed above the existing gas meter as shown on the Drawings. Cut and patch wall for new pipes into building when they will connect to existing gas lines, thence to the apartments.

One gas range must be disconnected from the common feed in every other apartment. Run new line in the basement from appropriate gas line to range for that apartment. This line must run tight to the floor and wall thru the bathroom into the kitchen cabinets to the range. Connect to range with gas cock.

Impact to Tenants

Electrical: Every other (alternate) apartments will require workmen to enter them to drill a hole thru for the new conduit feeders. Some cutting, patching and painting.

Gas: Every other apartment must be worked in to rework the gas range connections. About seven hours per apartment. Holes will have to be drilled in base cabinets, patched, etc. for new piping. Gas service could be interrupted for two days per apartment.

Cost Estimates:

Electrical Work:	3 bedroom	\$1,050/unit	\$53,300
	4 bedroom	\$2,500/unit	\$34,100
Gas Work			

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FORRESTAL VILLAGE
2ND INCREMENT MCON

a. 23 units - 4 apartments per unit

Buildings numbered 3698 through 3702, 3074, 3706, 3707, 3708, 3711 through 3716, 3718, 3720, 3721, 3723, 3724, and 3726 through 3728.

Buildings number 3702 and 3704 were investigated.

b. 8 units - 6 apartments per unit

Buildings numbered 3703, 3705, 3790, 3710, 3717, 3719, 3722 and 3725.

Buildings number 3703 and 3705 were investigated.

Building 3702 is a 4 apartment unit with 2 one story 2 bedroom apartments and 2 two story 2 bedroom apartments. There is a central utility room.

Building 3703 is a 6 apartment unit with 4 two story 2 bedroom apartments and 2 one story 2 bedroom apartments. There is a central utility room.

Building 3704 is a 4 apartment unit with 4 two story 3 bedroom apartments and a central utility room.

Building 3705 is a 6 apartment unit with 6 two story 4 bedroom apartments and a central utility room.

Electrical service feeds apartment panels, house panel, individual window air conditioning units and storage units.

Gas service feeds a central boiler, ranges, dryers, and central domestic hot water heater.

Refer to Drawings 3702 - E-1, 3703 - E-1, 3704 - E-1, 3705 - E-1 and to the photographs for electrical work.

Refer to Drawings 3703-3A and 4A, 3704-3A and 4A and 3705-3A and 4A for gas, heating, and DHW work. Also, see photographs.

Proposed Solutions

Electrical: Refer to Drawings and photographs.

New meters will be installed ahead of the existing fused disconnects to meter each apartment and a house meter. Some cutting, patching and painting will be required.

Gas: Refer to Drawings and photographs.

New meter will be installed on wall behind boiler room above existing meter (see Drawing 3703-4A). Piping from these meters shall run into the boiler room, then rise into the attic space. The existing boiler is not gas metered because it is being metered with BTU meters. A meter would be provided for it.

New gas lines will have to be run through attic spaces and up (and down) through the soffits. The services to isolate ranges and dryers from common lines to individual will have to run all new. If new domestic hot water heaters are required, they will be fed from these lines also.

Domestic hot water will have to be provided by installing new 30 gallon gas fired hot water heaters, in each apartment, in its utility room. Existing hot and cold water piping will have to be revised. Flues will rise in the utility room thru the roof or, in two story units, tie flues together (rooms are back to back) for two heaters, rise up in utility room, offset into corner of bathroom upstairs, then thru roof. Build chase.

Heating: A central boiler in each unit provides hot water heat to all apartments in the unit.

The individual apartments have a thermostat operating a 3-way control valve located in either a closet or under the staircase.

A BTU meter shall be installed in the hot water return with temperature sensors located in both the supply and return. A remote counter for either BTU, GPM or both can be provided for distances over five hundred feet.

We recommend that the electrical energy be metered as the per apartment cost and inconvenience to tenants is reasonable.

Storage units have small (60 watt) porcelain light fixtures in each unit. They are fed out of apartment panels. However, one apartment feeds two units. Thus, every other apartment does not have a unit on its panel while every other apartment has two units. Because of the small power consumed by and low usage of the storage units we did not call for the electrical work to remove every other storage shed light to its respective panel. Cost of rewiring, cutting concrete sidewalks, patching, painting, etc. would run about $1,500 per unit. We recommend it not be done. We did not include it in our estimate.

However, we recommend against the individual domestic hot water heaters and their flues. Again, we recommend the hot water be supplied, as is, from the central heater.

The changes in gas piping will be messy and cause a great deal of inconvenience to the tenants. The cost per apartment is quite high. Space will be lost out of the apartment utility rooms in already small quarters.

The heating metering will be fairly simple but costly at least $2,600 per apartment.

If some way of pro-rating the gas, heat and hot water could be worked out, we highly recommend it.

<u>Impact to Tenants</u>

<u>Electrical</u>: Power outage could last two days. No work would be required in the individual apartments.

<u>Gas</u>: Considerable work will be required in each apartment. Cutting, patching, painting, insulating, roofing, and gas shutoff for at least two weeks. Each apartment is effected as piping runs thru each to the next apartment. Really messy.

<u>Heating</u>: A small amount of cutting and patching will be required. Not too much inconvenience since work is done in each apartment storage room. Down time would be a week, obviously during mild or hot weather.

<u>Cost Estimates</u>:

Electrical Work	$ 95,600
Gas Work	$260,500

Domestic hot water heaters included.

Heating		$308,000
$2,200 per apartment -	92 apartments x $2,200 = $202,400	
	48 apartments x $2,200 = $105,600	

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NIMITZ VILLAGE
2ND INCREMENT MCON

5 units - 4 apartments per unit

Buildings numbered 4064 through 4068.

Buildings number 4064 and 4068 were investigated.

Buildings 4064 and 4068 are almost identical. They consist of 4 apartments. 2 single story 2 bedroom and 2 two story bedroom apartments.

A central boiler provides hot water heat. A central domestic hot water heater provides hot water. Each apartment has a gas range and a gas dryer. The building has a total gas meter.

There is no electric metering at present. There are individual apartment electrical panels and a house panel. Storage units have a 60 watt light fixture fed from an apartment panel alternately so one apartment feeds two storage units while the alternate apartment feeds none.

Refer to Drawings 4068 - E-1 and the photographs for electrical work.

Refer to Drawings 4064-3A, 4064-4A and to the photographs for the gas piping and domestic hot water work.

Proposed Solutions

Electrical: Install four new meters on primary side of existing disconnects. Install new meter for "house" service. Group meters on exterior wall where existing service enters the building.

Gas: Install four new meters on wall behind boiler room above existing meter. Run piping in attic and route as shown on the sketches (Drawings 4064-4A). Piping will run in the soffit. Cutting and patching will be required. New runs to isolate the ranges and dryers will be required. New water heaters will have to be connected also.

Heating: A central boiler is presently BTU metered. Buildings 4064 thru 4068 have a gas fired hot water boiler for each building. The individual apartments have a thermostat operating a 3-way control valve located in either a closet or under the staircase.

A BTU meter can be installed in the hot water return with temperature sensors located in both the supply and return. A remote counter for either BTU, GPM or both can be provided for distances over five hundred feet.

Domestic Hot Water: New 30 gallon gas fired water heaters will be installed in each apartment in their utility room. This will require revisions in the water piping, cutting, patching, painting. Flues will have to be installed thru the roofs.

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We recommend that the electrical energy be metered as the per apartment cost and inconvenience to tenants is reasonable.

Storage units have small (60 watt) porcelain light fixtures in each unit. They are fed out of apartment panels. However, one apartment feeds two units. Thus, every other apartment does not have a unit on its panel while every other apartment has two units. Because of the small power consumed by and low usage of the storage units, we did not call for the electrical work to remove every other storage shed light to its respective panel. Cost of rewiring, cutting concrete sidewalks, patching, painting, etc. would run about $1,500 per unit. We recommend it not be done. We did not include it in our estimate.

However, we recommend against the individual domestic hot water heaters and their flues. Again, we recommend the hot water be supplied, as is, from the central heater.

The changes in gas piping will be messy and cause a great deal of inconvenience to the tenants. The cost per apartment is quite high. Space will be lost out of the apartment utility rooms in already small quarters.

The heating metering will be fairly simple but costly at least $2,600 per apartment.

If some way of pro-rating the gas, heat and hot water could be worked out, we highly recommend it.

Impact to Tenants

Electrical: Power outage could last two days. No work would be required in the individual apartments.

Gas: Considerable work will be required in each apartment. Cutting, patching, painting, insulating, roofing, and gas shutoff for at least two weeks. Each apartment is effected as piping runs thru each to the next apartment. Really messy.

Heating: A small amount of cutting and patching will be required. Not too much inconvenience since work is done in each apartment storage room. Down time could be a week, obviously during mild or hot weather.

Cost Estimates:

Electrical Work 5 units at $2,800 each	$14,000
Gas Work 5 units at $1,875 each - Includes domestic hot water work.	$37,500
Heating 20 apartments at $2,600 each	$52,000

MAIN SIDE
FOSS ACRES

a. 1 unit - 3 apartments

Building number 67Q

Building 67Q was investigated.

b. 1 unit - 4 apartments

Building number 65Q

Building 65Q was investigated.

c. 1 unit - 6 apartments

Building number 66Q

Building 66Q was investigated.

The 3 units form a close complex served from a central utility area in the basement under building 66Q.

A central gas fired hot water boiler provides heat which is distributed to each apartment but not so each pipe is a zone. A central domestic hot water heater distributes hot water to each apartment similar to the hot water heat.

Each apartment is served with an individual gas service and can be easily metered.

The electrical service distributes from the central area under building 66 out to each apartment. Unfortunately the distribution for the washers and dryers comes from the central panels and not from each apartment.

Please refer to Drawing Q65-E-1 and the photographs for electrical work.

Please refer to Drawings 66-2, 66-3, 66-4, and 65-3 and the photographs.

Proposed Solutions

Electrical: Refer to Drawing Q65-E-1. Provide a new meter, main breaker, and panel for each unit. New panel to have 100/2P breaker to feed existing apartment panels. In addition it will require 2-30/2P and 3-20/1P breakers to feed the washer, dryer, air conditioner and garage service.

New meters will be located on the west exterior wall of the garage and thence feed underground to the new panel to be located in the empty room adjacent to the boiler room.

The existing washer and dryer outlets shall be extended to the new apartment distribution panels. The light and receptacle in each storage area shall be disconnected and rewired back to the appropriate distribution panel.

The lights and receptacles in the garage areas shall be abandoned, new receptacles and lights installed (one per car area) and wired back to the appropriate panel.

The existing main electrical service shall be extended to the new service meter location.

Gas: The gas services are already set up to be separately metered. Install new meters in each apartment line. Since there are receptacles for electric dryers and we noted only one gas dryer, we did not allow for providing gas outlets for each tenants dryers.

Domestic Hot Water: Install individual hot water heaters in accordance with Drawings shown on 66-3.

Heating: Buildings Q-65, 66 and 67 have a central gas fired hot water boiler located in building Q-66. The hot water heating system is not zoned per individual apartment. This system also is used to heat the garage areas serving the three buildings. The heat has been shut off to the garage.

The piping in the basement would be modified so that each apartment is an individual zone with a BTU meter to totalize energy usage. The heat in the garage should be either deleted or placed on an unmetered common zone.

Impact to Tenants

Electrical: Power will be out for about seven days when final cut over and removal of the wiring in the basement begins. Proper phasing of the work might reduce this time but running into so many pipes, etc. will make this work difficult.

Gas: Service would be interrupted for from 4 to 16 hours depending on the possible phasing of the metering arrangement, etc. prior to manifolding the main service set up. Service may be able to be maintained to each apartment not having its line interrupted for installing its meter.

Domestic Hot Water: The tenants will be inconvenienced in several ways. Cutting, patching of cabinets, floors, roof, etc. will be required. New gas lines run. Tenants will have Contractors in and out for at least five days per apartment.

Heating: If done during non-heating season very little bother to tenants. System will have to be rebalanced and air bled off in each apartment before start up.

Recommendations

Alternate Solutions:

Electrical: Do not make any effort to meter apartments. The way in which the air conditioners, dryers, washers, garages and storage units are fed centrally makes any effort to collect each apartments loads to meter them very costly. The age of the building hardly warrants a complete rewiring, especially since it was completely rewired recently for new main services and wiring for the appliances already mentioned.

The existing apartment panels could be easily metered but with the dryer, washer and air conditioner not on the meter it would make little sense.

Gas: Gas could be easily metered but all you would be metering is the range, assuming individual hot water heaters are not installed.

Domestic Hot Water: We recommend against installing individual water heaters because of the high cost of installing, messy work, and the hardship the space taken up by water heater would put on tenants whose apartments are small anyway.

Heating: We recommend not repiping the hot water because of the high cost per apartment necessary to isolate each service. We also are afraid maybe some of the services may not be easily isolated. Messy work. Since as-built drawings were observed to be inaccurate, we question how reliable they were and, therefore, are nervous about the piping arrangements.

Age and size of units also is a factor. We deem this very unfeasible.

Overall, we would recommend that Foss Acres be left as is in every way.

The cost per apartment works out to be $8,513 to do all the required work to meter separately all sources. This would be about half the cost of or more of the entire cost to building 13 new apartments.

Cost Estimates:

Electrical	$51,670
Gas (includes domestic hot water)	$13,500
Heating	$45,500

FORRESTAL VILLAGE
GARAGES

Note: Because of the nature of the garages, the format varies slightly here, as each garage unit is addresed separately.

14 units - 6 stalls per unit

Buildings numbered 2257, 2350, 2382, 2393, 2448, 2449, 2483, 2484, 2639, 2681, 2850, 2946 and 2948.

Each stall contains one light fixture, one switch and one receptacle. Presently each unit is fed from an aerial service drop, adjacent to the unit, to a disconnect switch mounted inside the unit.

See Drawing 14-6-E-1 for proposed solution. See photographs.

Proposed Solutions

Electrical: Each stall will require a separate 120 volt circuit, which shall extend to a new disconnect switch mounted on wall of garage. Each disconnect switch shall be connected to the load side of a new meter located on exterior of garage wall. A total of 6 new meters will be required.

It is our recommendation that only one meter be installed for all six stalls and the charges be equally shared by the 6 responsible parties, if indeed any metering is required. Almost negligible power is used here. No appliances were found and no lights were on when we investigated the garages.

Gas: None.

Impact to Tenants

None.

Cost Estimates:

Electrical Work = $2,500 x 14 units = $35,000

HOSPITAL
GARAGES

1 unit - 5 stalls

Building number 59H.

Each stall contains one light fixture, one switch and one receptacle. Presently each unit is fed from a disconnect switch mounted inside the unit.

See Drawing 59H-5-E-1. See photographs.

Proposed Solutions

Electrical: Each stall will require a separate 120 volt circuit, which shall extend to a new disconnect switch mounted on wall of garage. Each disconnect switch shall be connected to the load side of a new meter located on exterior of garage wall. A total of 5 new meters will be required.

It is our recommendation that one meter be installed for all 5 stalls and the charges be equally shared by the 5 responsible parties.

Gas: None.

Impact to Tenants

None.

Cost Estimates:

Electrical Work $2,100

1500 1. 5 new meters
250 2. 5 new disconnect switches
3.

88.00	Stall #1	70 ft. of 1/2"C & 140 ft. #12 wire
76.00	Stall #2	60 ft. of 1/2"C & 120 ft. #12 wire
63.00	Stall #3	50 ft. of 1/2"C & 100 ft. #12 wire
51.00	Stall #4	40 ft. of 1/2"C & 80 ft. #12 wire
39.00	Stall #5	30 ft. of 1/2"C & 60 ft. #12 wire

2,067 = 2,100

FORRESTAL VILLAGE
STORAGE BUILDINGS

Note: Because of the nature of the storage buildings, the format varies slightly here, as each storage building unit is addressed separately.

36 units - 4 storage rooms per unit

Each storage room contains one porcelain lampholder controlled with a switch. Presently each unit is fed underground, from the utility room of an adjacent building, to a disconnect switch mounted on the exterior of the storage building.

See Drawing 36-4-E-1 for proposed solution. See photographs.

Proposed Solutions

Electrical: Each storage room will require a separate 120 volt circuit, which shall extend, underground, to a breaker in the main distribution panel of the apartment associated with each particular storage room.

We re.ommend that a separate meter be installed in the circuit that is presently feeding each building, and the charges be equally shared by the 4 responsible parties.

Gas: None.

Impact to Tenants

None.

Cost Estimates:

Electrical Work	$1,600

4 rooms x $400 per room = $1,600

FORRESTAL VILLAGE
STORAGE BUILDINGS

8 units - 8 storage rooms per unit

Each storage room contains one porcelain lampholder controlled with a switch. Presently each unit is fed underground from the utility room of an adjacent building to a disconnect switch mounted on the exterior of the storage building.

See Drawing 8-8-E-1 for proposed solution. See photographs.

Proposed Solutions

Electrical: Each storage room will require a separate 120 volt circuit, which shall extend, underground, to a breaker in the main distribution panel of the apartment associated with each particular storage room.

We recommend that a separate meter be installed in the circuit that is presently feeding each building, and the charges be equally shared by the 8 responsible parties.

Gas: None.

Impact to Tenants

None.

Cost Estimates:

Electrical Work	$3,200

8 rooms x $400 per room = $3,200

PHASE III, HOUSING METER STUDY

MARINE CORPS DEVELOPMENT AND EDUCATION COMMAND QUANTICO, VA.

APRIL, 1978

CONTRACT N62477-78-C-2016

GAUTHIER, ALVARADO & ASSOCIATES

STUDY OBJECTIVES

- CONGRESS HAS MANDATED THROUGH PUBLIC LAW 95-82 (1978 MILITARY CONSTRUCTION AUTHORIZATION ACT) THAT THE SECRETARY OF DEFENSE CONDUCT A TEST OF METERING ENERGY CONSUMPTION IN MILITARY FAMILY HOUSING. THE SECRETARY OF DEFENSE, CONSEQUENTLY, HAS SELECTED TEN INSTALLATIONS OF MILITARY HOUSING TO BE TESTED; THE MILITARY HOUSING INSTALLATIONS AT THE MARINE CORPS DEVELOPMENT AND EDUCATION COMMAND (MCDEC, AT QUANTICO, VA) HAS BEEN DESIGNATED AS ONE OF THESE TEN.

THIS STUDY ADDRESSES THE INSTALLATION OF METERING IN 650 MULTIPLE-FAMILY HOUSING UNITS AT MCDEC WHICH REQUIRE INDIVIDUAL METERING, ITS COST, ITS IMPACT UPON THE SERVICES PROVIDING ENERGY TO THE UNITS, AND ITS IMPACT UPON THE ENFORCED VACANCY OF THE UNITS DURING THE CONSTRUCTION CHANGEOVER PERIOD.

THE STRUCTURES EXAMINED CONSISTS OF APARTMENT BUILDINGS, SPLIT LEVEL CONDOMINIUMS-TYPE UNITS, AND DUPLEX HOUSING UNITS. THE UNITS ARE PROVIDED ENERGY IN DIFFERENT FORMS, ELECTRIC, GAS, STEAM OR HOT WATER; MOST BUILDINGS UTILIZE AT LEAST TWO TYPES OF ENERGY AND MANY UTILIZE ALL FOUR TYPES. THE ORIGINAL BUILDING SYSTEMS ARE GENERALLY CENTRAL UNIT SYSTEMS PROVIDING ELECTRICITY, HEAT, OR DOMESTIC HOT WATER TO ALL HOUSING UNITS IN THE SAME BUILDING THROUGH COMMON RISERS, WIRING, PIPING, ETC.

TO ACCOMMODATE THE INDIVIDUAL METERING OF HOUSING UNITS, THE CENTAL COMMON DISTRIBUTION SYSTEMS MUST BE REVISED TO PROVIDE INDIVIDUAL SERVICE OF EACH TYPE OF ENERGY USED TO EACH HOUSING UNIT. CONSEQUENTLY, IN MANY OF THE MULTI-FAMILY HOUSING BUILDINGS A MAJOR REVISION OF THE INTERIOR DISTRIBUTION IS NECESSARY TO ENABLE THE INSTALLATION OF INDIVIDUAL METERING FOR MONITORING OF THE ENERGY CONSUMPTION OF EACH HOUSING UNIT. IN ADDITION, COMMON AREAS MUST BE MONITORED BY THE USE OF HOUSE METERS.

THE OBJECTIVE OF THE STUDY IS TO IDENTIFY THE MAGNITUDE OF THE PROPOSED PROJECT IN TERMS OF CONSTRUCTION COST, TECHNICAL COMPLEXITY, AND VACANCY IMPACT, TO FULLY METER EVERY ENERGY INPUT TO THE 650 FAMILY HOUSING UNITS, SPECIFICALLY THE ENERGY INPUT THROUGH UTILITY SERVICES CONSISTING OF ELECTRICITY, GAS, STEAM/HOT WATER.

THE STUDY INCLUDES DIVIDING THE TOTAL HOUSING UNITS INTO TYPICAL BUILDING TYPES.PROVIDED FOR EACH BUILDING TYPE ARE, DRAWINGS OF THE EXISTING AS-BUILT SERVICES, SKETCHES OF SOLUTIONS FOR THE PROPOSED METERING OF EACH ENERGY SERVICE TO EACH INDIVIDUAL HOUSING UNIT WITHIN THE BUILDING, A COST ESTIMATE IN 1978 DOLLARS FOR THE ENTIRE PROPOSED PROJECT AND THE ESTIMATED FORCED VACANCY TIME REQUIRED TO PERFORM THE CONSTRUCTION. THIS VACANCY PERIOD EXTENDS FROM WEEK FOR SOME UNITS TO SEVERAL WEEKS FOR THE MORE COMPLEX APARTMENT BUILDINGS.

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SYNOPSIS

BUILDING TYPE	UTILITIES INVOLVED (2)	NUMBER OF DWELLING UNITS	METERING COST PER DWELLING UNIT	AVERAGE COST PER BUILDING	TOTAL COST ALL UNITS
Lettered Apts. (Steam Heat)	S,G,E	72	16,088 (3)	96,526	1,158,312.
Lettered Apts. (Hot Water Heat)	S,G,E	42	36,495 (3)	218,965	1,532,755.
2000 Block Apts.	S,G,E	96	14,448 (3)	86,688	1,387,008.
Thomason Park	G,E	170	2,621	17,824	445,597.
300 Block Split Level	G,E	77	2,087	8,035	160,706.
2000 Block Split Level	G,E	12	2,690	10,759	32,277.
2700 Block Split Level	G,E	125	2,064	8,321	257,940.
2700 Block Duplex	G,E	20	1,857	3,713	37,130.
800 Block Duplex	S,G,E	10	1,888	3,776	18,886.
Bldg. 3079	S,G,E	13	6,420 (3)	83,454	83,454.
Bldg. 2207	S,G,E	11	11,038 (3)	121,414	121,414.
Water Works	E,F	2	3,350	3,350	6,700.
GRAND TOTAL		650	8,065	36,917	5,242,173.

(1) All estimates are in current (July 1978) dollars.

(2) S-Steam, G-Gas, E-Electric, F-Fuel Oil.

(3) Metering cost in these buildings is higher because of extensive rewiring and repiping required in the entire building.

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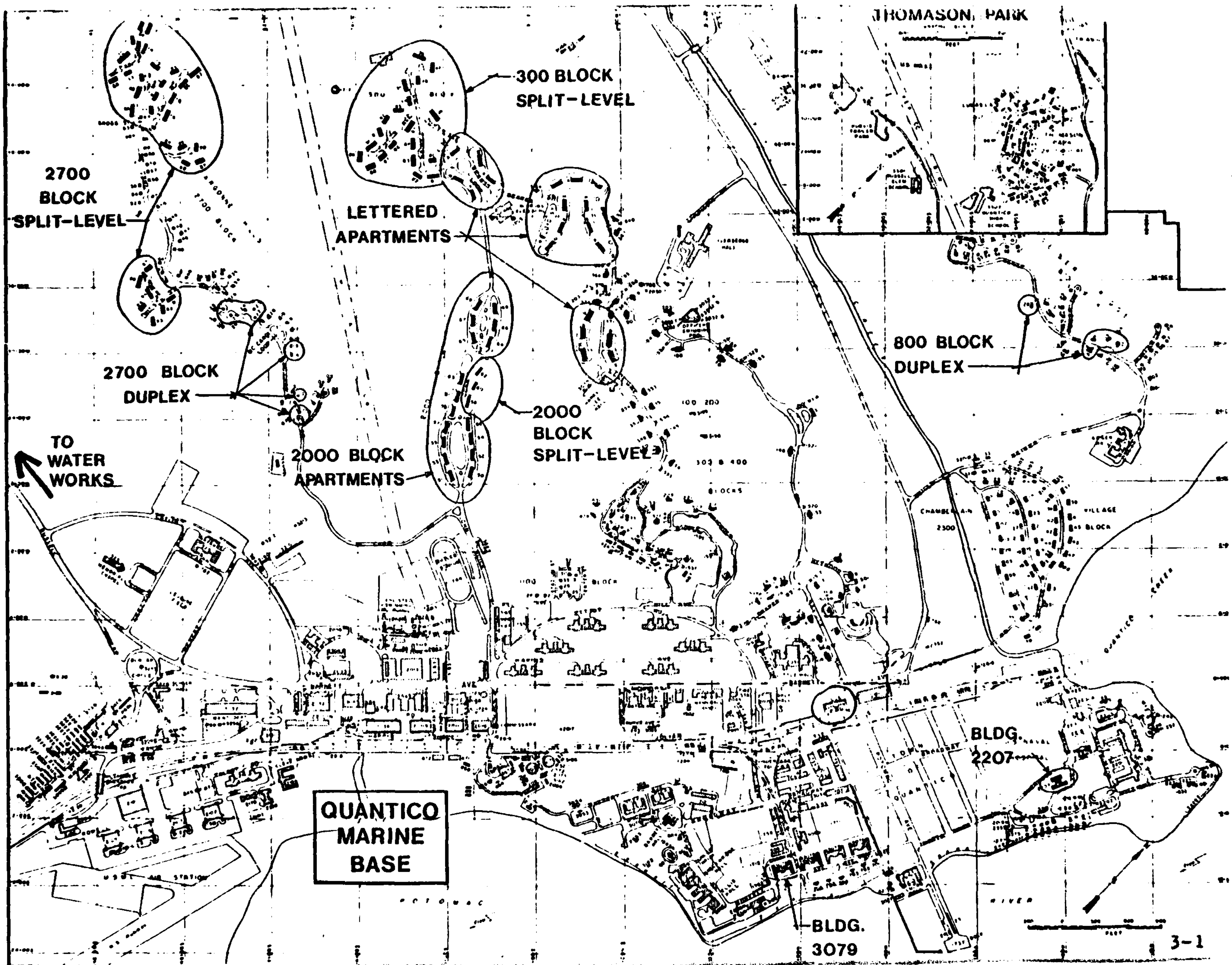
SITE PLAN


THOMASON PARK
300 BLOCK
SPLIT-LEVEL
2700
BLOCK
SPLIT-LEVEL
LETTERED
APARTMENTS
800 BLOCK
DUPLEX
2700 BLOCK
DUPLEX
2000
BLOCK
SPLIT-LEVEL
TO
WATER
WORKS
2000 BLOCK
APARTMENTS
BLDG.
2207
QUANTICO
MARINE
BASE
BLDG.
3079

4

BUILDING TYPES

BUILDING TYPES	NO. OF DWELLING UNITS	NO. OF BUILDINGS
LETTERED APARTMENTS	114	19
2000 BLOCK APARTMENTS	96	16
THOMASON PARK	170	36
300 BLOCK SPLIT LEVEL	77	20
2000 BLOCK SPLIT LEVEL	12	3
2700 BLOCK SPLIT LEVEL	125	31
2700 BLOCK DUPLEX	20	10
800 BLOCK DUPLEX	10	5
APARTMENT BUILDING 3079	13	1
APARTMENT BUILDING 2207	1[illegible]	1
WATER WORKS	2	2

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NARRATIVES

NARRATIVE INDEX

LETTERED APARTMENT

LETTERED APARTMENTS

GENERAL

THERE ARE 19 BUILDINGS IN THE "LETTERED APARTMENT" ENCLAVE WHICH TRANSLATES INTO 114 LIVING UNITS. THESE BUILDINGS ARE LOCATED IN THE NORTH WEST SECTION OF THE QUANTICO MARINE BASE AND ARE ACCESSIBLE FROM NEVILLE ROAD AND LEJEUNE ROAD.

CONSTRUCTED APPROXIMATELY 45 YEARS AGO, THE BUILDINGS HAVE THREE LEVELS OF LIVING UNITS, A BASEMENT LEVEL AND AN ATTIC. EACH LEVEL OF LIVING UNITS CONSISTS OF TWO APARTMENTS OPENING ONTO A CENTRAL STAIRWELL AND THE ATTIC SPACE ORIGINALLY DESIGNED AS EXTRA BEDROOMS FOR THE APARTMENTS BELOW HAVE SINCE BEEN CONVERTED INTO STUDY ROOMS FOR THE TENANTS' USE. A PORTION OF THE BASEMENT HOUSES THE BASIC UTILITIES SERVING THE OCCUPANTS AND THE BALANCE OF THE SPACE IS DIVIDED INTO INDIVIDUAL STORAGE SPACES AND GARAGES WHICH ARE ACCESSIBLE FROM GRADE LEVEL IN THE REAR OF THE BUILDINGS.

THE UNITS ARE GENERALLY CONSTRUCTED OF CONCRETE WITH EXTERIOR WALLS OF BRICK. SLATE WAS USED AS THE ROOFING MATERIAL AND THE WINDOWS ARE DOUBLE HUNG WITH SINGLE GLAZING.

DESCRIPTIONS OF THE SYSTEMS SERVING THE LIVING UNITS AND AN EXPLANATION OF THE MODIFICATIONS TO THOSE SYSTEMS TO ACCOMPLISH THE REQUIRED METERING ARE CONTAINED WITHIN THE FOLLOWING PARAGRAPHS. TO ACCOMPLISH THE PHYSICAL CHANGES NECESSARY TO FACILITATE THE INSTALLATION OF METERS WOULD REQUIRE EACH BUILDING TO BE VACATED FOR A MINIMUM OF FOUR WEEKS.

ELECTRICAL SERVICE

EXISTING

THE EXISTING ELECTRICAL SERVICE IS UNDERGROUND TO A MAIN DISTRIBUTION PANEL IN THE BASEMENT. THREE INDIVIDUAL APARTMENT PANELS ARE FED IN COMMON FROM EACH OF TWO FEEDERS RADIATING FROM THE MAIN DISTRIBUTION PANEL. THIS PANEL ALSO FEEDS A SECOND PANEL IN THE BASEMENT AREA WHICH SERVES ALL HOUSE POWER AND LIGHTING AND ALL TENANT OWNED WASHING MACHINES, DRYERS, AND STORAGE SPACES. MANY STORAGE SPACES HAVE INDIVIDUALLY OWNED FREEZERS. THE ATTIC SPACE OF THIS BUILDING HAS SIX ADDITIONAL SPACES ALLOCATED TO EACH APARTMENT.

PROPOSED METERING

THE SPORADIC LOCATION OF TENANT OWNED ELECTRICITY CONSUMING APPLIANCES, THE REMOTE ATTIC SPACES, AND THE COMMON FEEDERS TO APARTMENT PANELS WILL REQUIRE THAT THESE BUILDINGS BE EXTENSIVELY REWIRED. THE BASIC SOLUTION WILL REQUIRE REPLACING THE MAIN DISTRIBUTION PANEL WITH A 7 POSITION METERED DISTRIBUTION PANEL. THIS PANEL WILL IN TURN FEED 7 PANELS DIRECTLY BESIDE THE NEW METERS. EACH OF SIX PANELS WILL SERVE THE SIX APARTMENTS AND ONE PANEL WILL SERVE COMMON HOUSE LOADS. THE NEW PANELS WILL HAVE NEW CIRCUITS TO FEED THE FOLLOWING FOR EACH TENANT:

1. EXISTING APARTMENT PANEL
2. WASHING MACHINE
3. DRYER
4. STORAGE SPACE IN BASEMENT (FREEZER)
5. STORAGE SPACE IN ATTIC SPACE
6. HOT WATER CIRCULATOR.

THE PANELS IN THE BASEMENT NOW FEEDING THESE LOADS WILL BECOME USELESS AND WILL BE ABANDONED.

DOMESTIC HOT WATER SERVICE

EXISTING

THE EXISTING DOMESTIC HOT WATER IS PROVIDED THROUGH A STEAM TO HOT WATER HEAT EXCHANGER. THE EXCHANGER, HOT WATER CIRCULATING PUMP AND THE STEAM CONTROL VALVE ARE LOCATED IN THE BASEMENT. HEAT EXCHANGER OPERATES ON LOW PRESSURE STEAM. HORIZONTAL MAINS CONSISTING OF HOT WATER PIPING AND HOT WATER CIRCULATING PIPING RUN EXPOSED AT CORRIDOR CEILING WITH NECESSARY TAPPING TO CLOTHES WASHERS LOCATED IN THE BASEMENT. NUMBER OF VERTICAL RISERS RUN IN EXISTING PIPE CHASES OR IN WALLS. THESE RISERS ARE TAPPED FOR KITCHEN AND BATHROOM REQUIREMENTS FOR EACH APARTMENT ON EVERY FLOOR. HOT WATER CIRCULATING PUMPS MAINTAIN CONSTANT TEMPERATURE OF HOT WATER AT ALL TIMES. LARGE PORTION OF PIPING IS NOT INSULATED RESULTING IN HEAT LOSS. PORTION OF PIPES RUN THRU UNHEATED AREAS.

PROPOSED STEAM METERING FOR HOT WATER SYSTEM:

EXISTING HEAT EXCHANGER, STEAM CONTROL VALVE, HOT WATER CIRCULATING PUMP AND ALL CONNECTING PIPING WILL BE REMOVED. SIX (6) STEAM TO WATER HEAT EXCHANGERS WITH STEAM CONTROL VALVES, HOT WATER CIRCULATING PUMPS AND ALL ACCESSORIES WILL BE INSTALLED IN THE EXISTING MECHANICAL ROOM LOCATED IN BASEMENT. EVERY APARTMENT WILL HAVE A SEPARATE HOT WATER SYSTEM WITH HOT WATER PIPING, PUMP, AND HOT WATER CIRCULATING PIPING. EXISTING HOT WATER CIRCULATING PIPING WILL BE REUSED AS MUCH AS POSSIBLE. NEW PIPING WILL RUN IN EXISTING PIPE CHASES OR IN EXISTING WALLS. EXISTING VERTICAL RISERS

SERVING APARTMENTS ON EVERY FLOOR WILL BE REMOVED AND NEW PIPING INSTALLED. NEW PIPING WILL BE INSULATED WITH 1/2" THICK INSULATION AND RUN EXPOSED AT CORRIDOR CEILING. VERTICAL RISERS WILL ALSO BE INSULATED. CONNECTION TO EQUIPMENT/FIXTURES WILL BE MADE AT EVERY FLOOR. SHUT-OFF VALVES WILL BE PROVIDED AT BASE OF VERTICAL RISERS AND ALSO AT BRANCH PIPING SERVING EACH APARTMENT. WASHERS, ONE FOR EACH APARTMENT LOCATED IN THE BASEMENT, WILL BE INDEPENDENTLY PIPED TO HOT WATER SYSTEM OF INDIVIDUAL APARTMENT. EACH CIRCULATING PUMP WILL BE WIRED INDEPENDENTLY TO INDIVIDUAL APARTMENTS ELECTRIC METER. SEPARATE HEAT EXCHANGER AND ALL CONNECTING PIPING WILL BE PROVIDED FOR LAUNDRY TRAY AND TOILET LOCATED IN THE BASEMENT. CIRCULATING PUMP FROM THIS SEPARATE SYSTEM SHOULD BE CONNECTED TO HOUSE ELECTRIC METER. HOT WATER PIPING WILL BE EXTENDED TO TOILETS LOCATED IN ATTIC.

GAS SERVICE

EXISTING

GAS MAIN ENTERS THE BUILDING AND SHUT-OFF VALVE WITH PRESSURE REGULATOR IS PROVIDED NEAR THE METERS. SIX METERS, ONE FOR EVERY APARTMENT, ARE LOCATED ON THE CORRIDOR WALL OF THE MECHANICAL ROOM. EVERY APARTMENT IS PIPED SEPARATELY FROM INDIVIDUAL METER. HORIZONTAL MAINS RUN EXPOSED AT CORRIDOR CEILING. VERTICAL RISERS SUPPLY GAS TO EVERY APARTMENT. SHUT-OFF VALVES ARE NOT PRESENTLY LOCATED ON SUPPLY MAINS. ONE GAS METER IN BUILDING "K" IS MISSING.

PROPOSED METERING

NO NEW SYSTEM/DISTRIBUTION IS REQUIRED. EXISTING METERS SHOULD BE CLEANED AND GAGES RESET. NEW SHUT-OFF VALVES WILL BE PROVIDED ON SUPPLY PIPING SERVING EACH APARTMENT. PROVIDE NEW GAS METER FOR ONE APARTMENT IN BUILDING "K".

HEATING SYSTEM

EXISTING

SEVEN OF THE NINETEEN LETTERED APARTMENT BUILDINGS ARE PRESENTLY HEATED WITH HOT WATER. THEY ARE BUILDINGS F, G, H, I, K, N AND O. AS BEFORE, A HIGH PRESSURE STEAM MAIN ENTERS EACH BUILDING IN THE BASEMENT AND PASSES THROUGH A PRESSURE REDUCING STATION. THE LOW PRESSURE MAIN THEN SPLITS INTO TWO BRANCHES. ONE BRANCH SERVES THE EXISTING DOMESTIC WATER HEAT EXCHANGER IN THE BASEMENT MECHANICAL ROOM. THE OTHER BRANCH SERVES THE EXISTING HEATING WATER CONVERTOR ALSO IN THE BASEMENT MECHANICAL ROOM. HOT WATER IS THEN SUPPLIED TO THE RADIATORS BY WAY OF COMMON RISERS AND RETURNED TO THE CONVERTOR THROUGH COMMON RETURNS. CIRCULATION IS MAINTAINED WITHIN THE SYSTEM BY A SINGLE PUMP INSTALLED IN THE RETURN PIPING. THIS PRIMARY CIRCULATOR IS LOCATED IN THE BASEMENT MECHANICAL ROOM. THE SYSTEM CAN ALSO BE OPERATED BY AN IDENTICAL BACK-UP CIRCULATOR IN CASE OF PRIMARY CIRCULATOR FAILURE.

PROPOSED METERING

ALL EXISTING HOT WATER SUPPLY AND RETURN PIPING MUST BE DISCONNECTED AND ABANDONED OR REMOVED. ONLY UNUSED EXISTING PIPING WHICH IS EXPOSED SHALL BE REMOVED. THE EXISTING HEATING WATER CONVERTOR, EXPANSION TANK, AIR SEPARATOR, CIRCULATORS AND CONTROLS WILL BE DISMANTLED AND REMOVED. LOW PRESSURE STEAM SUPPLY PIPING WILL BE REMOVED BACK TO THE PRESSURE REDUCING STATION. A NEW STEAM-TO-WATER HEATING CONVERTOR WILL BE INSTALLED FOR EACH APARTMENT. ONE ADDITIONAL CONVERTOR WILL BE REQUIRED TO HEAT COMMON AREAS. NEW LOW PRESSURE STEAM SUPPLY WITH APPROPRIATE VALVING AND CONTROLS WILL BE INSTALLED FOR EACH CONVERTOR AND EACH DOMESTIC WATER HEATER. FOR THE PURPOSE

OF METERING ENERGY USAGE, SEVEN NEW CONDENSATE METERS WILL BE INSTALLED IN THE MECHANICAL ROOM THESE METERS WILL MEASURE THE FLOW OF STEAM CONDENSATE FROM THE CONVERTORS. CONDENSATE RETURNS FROM THE NEW DOMESTIC WATER HEATERS FOR EACH APARTMENT WILL BE TIED INTO THE APPROPRIATE HEATING CONDENSATE RETURN LINE JUST AHEAD OF THE NEW METERS. SEVEN NEW HOT WATER CIRCULATORS, EXPANSION TANKS, AIR SEPARATORS, VALVING AND CONTROLS WILL BE REQUIRED. ELECTRICITY FOR THE CIRCULATORS WILL COME FROM THE APPROPRIATE APARTMENT ELECTRICAL PANEL. ALL EXISTING RADIATORS CAN REMAIN. ALL NEW VERTICAL HOT WATER PIPING SHOULD BE INSTALLED IN CLOSETS OR EXISTING PIPE CHASES, WHEREVER POSSIBLE. IN CASES WHERE NEW VERTICAL PIPING MUST PASS THROUGH LIVING SPACES, IT SHOULD BE RUN IN CORNERS AND FURRED OUT CREATING A NEW PIPE CHASE. ALL NEW STEAM SUPPLY, HOT WATER SUPPLY, AND HOT WATER RETURN PIPING MUST BE INSULATED. SINCE THE NEW CONDENSATE PIPING WILL BE INSTALLED ONLY IN THE BASEMENT MECHANICAL ROOM AND IS PIPED TO A DRAIN, THESE NEW CONDENSATE LINES WILL BE INSULATED.

HEATING SYSTEM

EXISTING

TWELVE OF THE NINETEEN LETTERED APARTMENT BUILDINGS ARE PRESENTLY HEATED WITH STEAM. THIS STEAM IS SUPPLIED BY A CENTRAL HEATING PLANT ELSEWHERE ON THE BASE AND DISTRIBUTED UNDER HIGH PRESSURE IN BURIED STEAM MAINS. A TAP OFF OF THIS MAIN ENTERS EACH BUILDING IN THE BASEMENT, PASSES THROUGH A PRESSURE REDUCING STATION AND THEN SPLITS INTO THREE LOW PRESSURE STEAM BRANCHES. ONE BRANCH SERVES THE EXISTING DOMESTIC WATER HEAT EXCHANGER IN THE BASEMENT MECHANICAL ROOM. THE TWO REMAINING BRANCHES EACH LOOP AROUND ONE-HALF OF THE BASEMENT AND SERVE THE STEAM RISERS TO EACH APARTMENT RADIATOR. RADIATORS ARE LINED UP VERTICALLY ABOVE ONE ANOTHER AND ARE PRESENTLY SERVED BY A COMMON STEAM SUPPLY RISER AND A COMMON CONDENSATE RETURN LINE. THESE VERTICAL RETURN LINES CARRY CONDENSED STEAM TO CONDENSATE RETURN LOOPS IN THE BASEMENT. THESE CONDENSATE LOOPS ARE THEN PIPED TO A DRAIN.

PROPOSED METERING

THE EXISTING CONDENSATE RETURN SYSTEM WILL BE BROKEN UP SO THAT EACH APARTMENT HAS ITS OWN VERTICAL RETURN PIPING AND RETURN LOOP IN THE BASEMENT. INDIVIDUAL APARTMENT CONDENSATE METERS CAN THEN BE INSTALLED IN THE MECHANICAL ROOM. SOME VERTICAL CONDENSATE PIPING CAN REMAIN. THE EXISTING STEAM HEATING SUPPLY SYSTEM CAN REMAIN WITHOUT ALTERATIONS. IT IS RECOMMENDED THAT NEW VERTICAL CONDENSATE PIPING BE INSTALLED IN CLOSETS OR EXISTING PIPE CHASES WHEREVER POSSIBLE. IN CASES WHERE NEW VERTICAL PIPING MUST PASS THROUGH LIVING SPACES IT SHOULD BE RUN IN CORNERS WITH EXISTING PIPING AND SHOULD BE FURRED OUT CREATING A NEW PIPE CHASE. A PORTION OF THE EXISTING STEAM SUPPLY PIPING TO

THE EXISTING DOMESTIC WATER HEAT EXCHANGER CAN REMAIN BUT INSTALLATION OF NEW DOMESTIC WATER HEATERS FOR EACH APARTMENT WILL REQUIRE NEW STEAM CONTROLS AND VALVING AND SOME NEW PIPING. NEW DOMESTIC WATER HEATERS WILL ALSO REQUIRE NEW CONDENSATE RETURN PIPING WHICH WILL BE TIED INTO THE APPROPRIATE HEATING CONDENSATE RETURN LINE JUST AHEAD OF THE NEW METERS. ALL VERTICAL CONDENSATE PIPING WILL BE INSULATED.

Symbol	Description
	CONNECTION OF PROPOSED WORK TO EXISTING
	DOMESTIC HOT WATER SUPPLY
	DOMESTIC HOT WATER RETURN
	COLD WATER SUPPLY
	REMOVE EXISTING PIPING
	ABANDON EXISTING PIPING
	EXIST. PIPING TO REMAIN
—LP—	LOW PRESSURE STEAM SUPPLY
—HP—	HIGH PRESSURE STEAM SUPPLY
—CR—	CONDENSATE RETURN
—G—	GAS PIPING
—HWS—	HOT WATER SUPPLY (HEATING)
—HWR—	HOT WATER RETURN (HEATING)
	EXISTING ELECTRICAL EQUIP.
	NEW ELECTRICAL EQUIP.
M	ELECTRIC METER
MDP	MAIN DISTRIBUTION PANEL

Abbreviation	Meaning
BLDG.	BUILDING
K	KITCHEN
B	BATH
APT.	APARTMENT
W	WASHER
EXIST.	EXISTING
FL.	FLOOR
MECH. RM.	MECHANICAL ROOM
BSM'T.	BASEMENT
QTR'S.	QUARTERS

Symbol	Description
	EXISTING CABLE OR CONDUIT
	NEW CABLE OR CONDUIT
	ELECTRICAL FUSES
	ELECTRICAL MOLDED CASE CIRCUIT BREAKER

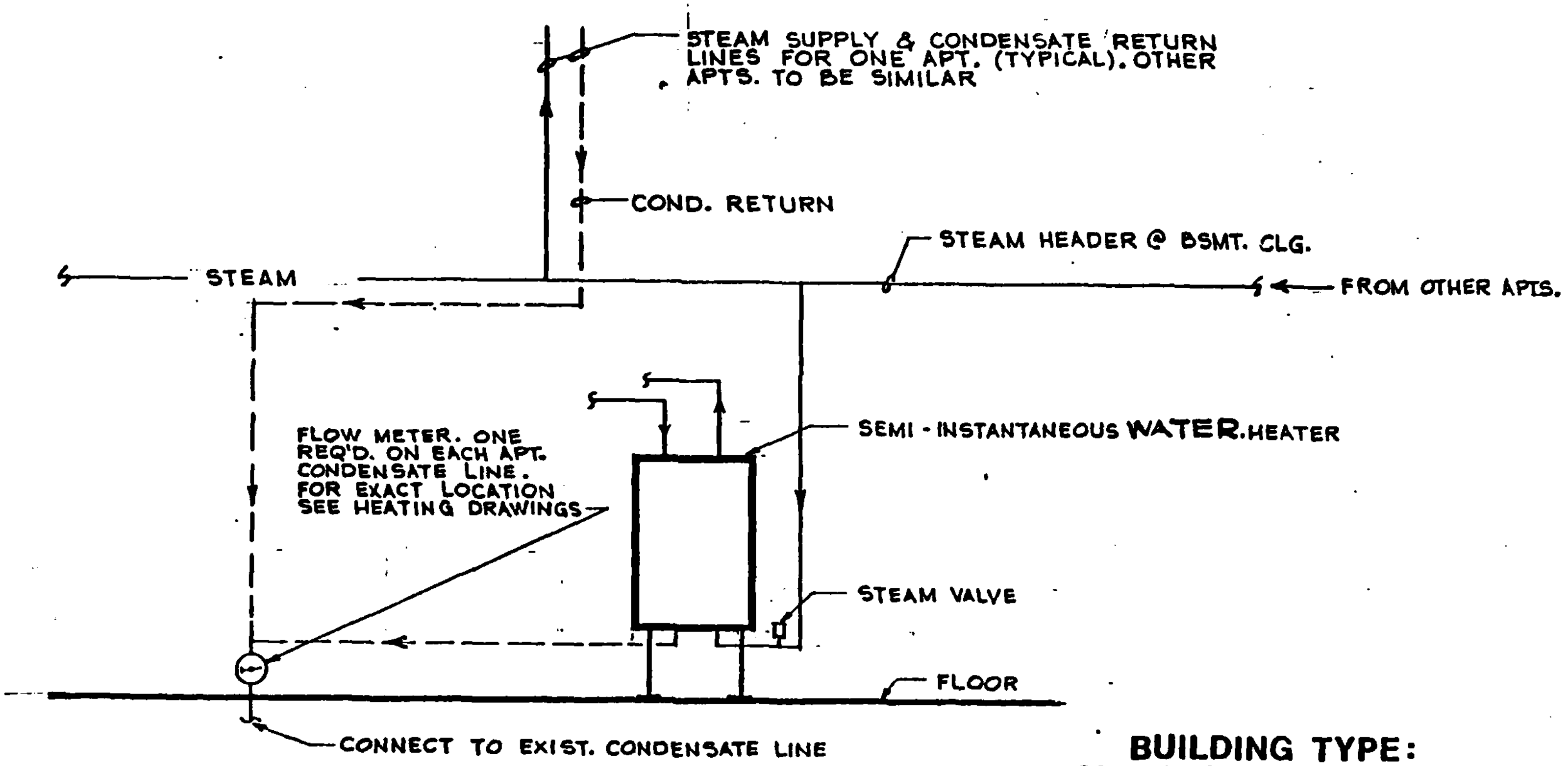
SYMBOLS & ABBREVIATIONS

BUILDING TYPE: ______

QUANTICO METER STUDY

SKETCH NUMBER: 1

GAUTHIER, ALVARADO & ASSOCIATES



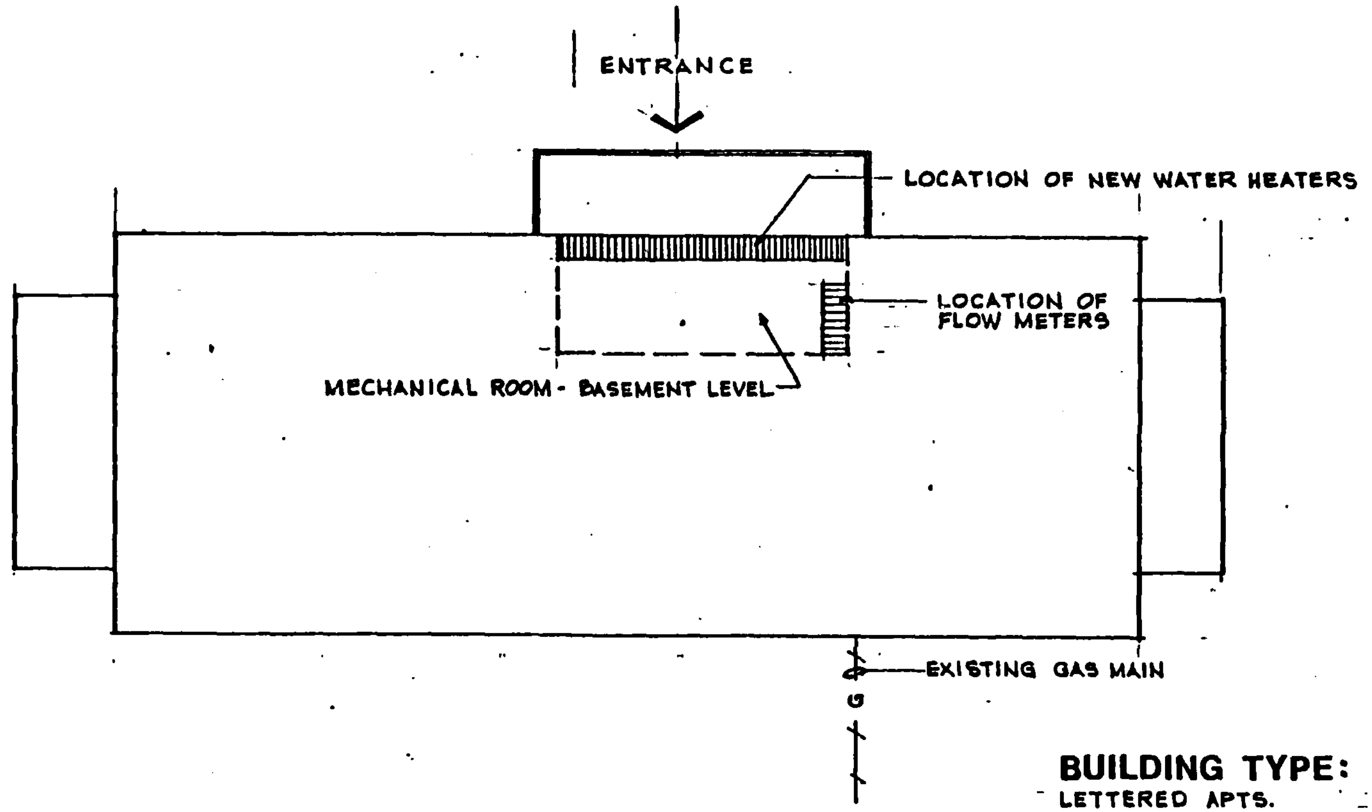
BUILDING TYPE:
2207, 3079, 2000 & LETTERED APTS.

QUANTICO METER STUDY

TYPICAL - STEAM SUPPLY & CONDENSATE RETURN PIPING FOR HOT WATER HEATER

SKETCH NUMBER: 2

GAUTHIER, ALVARADO & ASSOCIATES



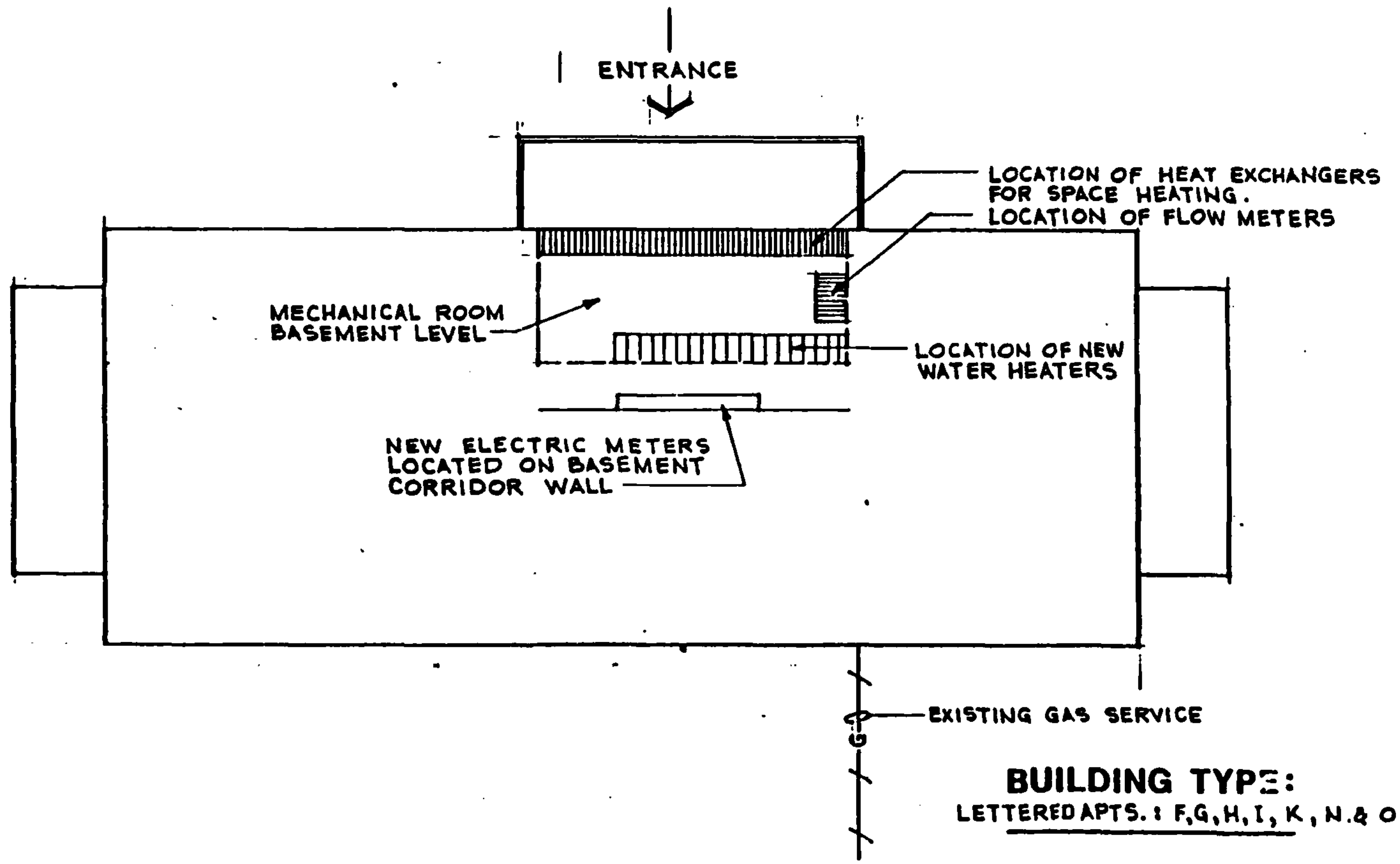
BUILDING TYPE:
LETTERED APTS.

QUANTICO METER STUDY

PLAN NTS

SKETCH NUMBER: 3

GAUTHIER, ALVARADO & ASSOCIATES



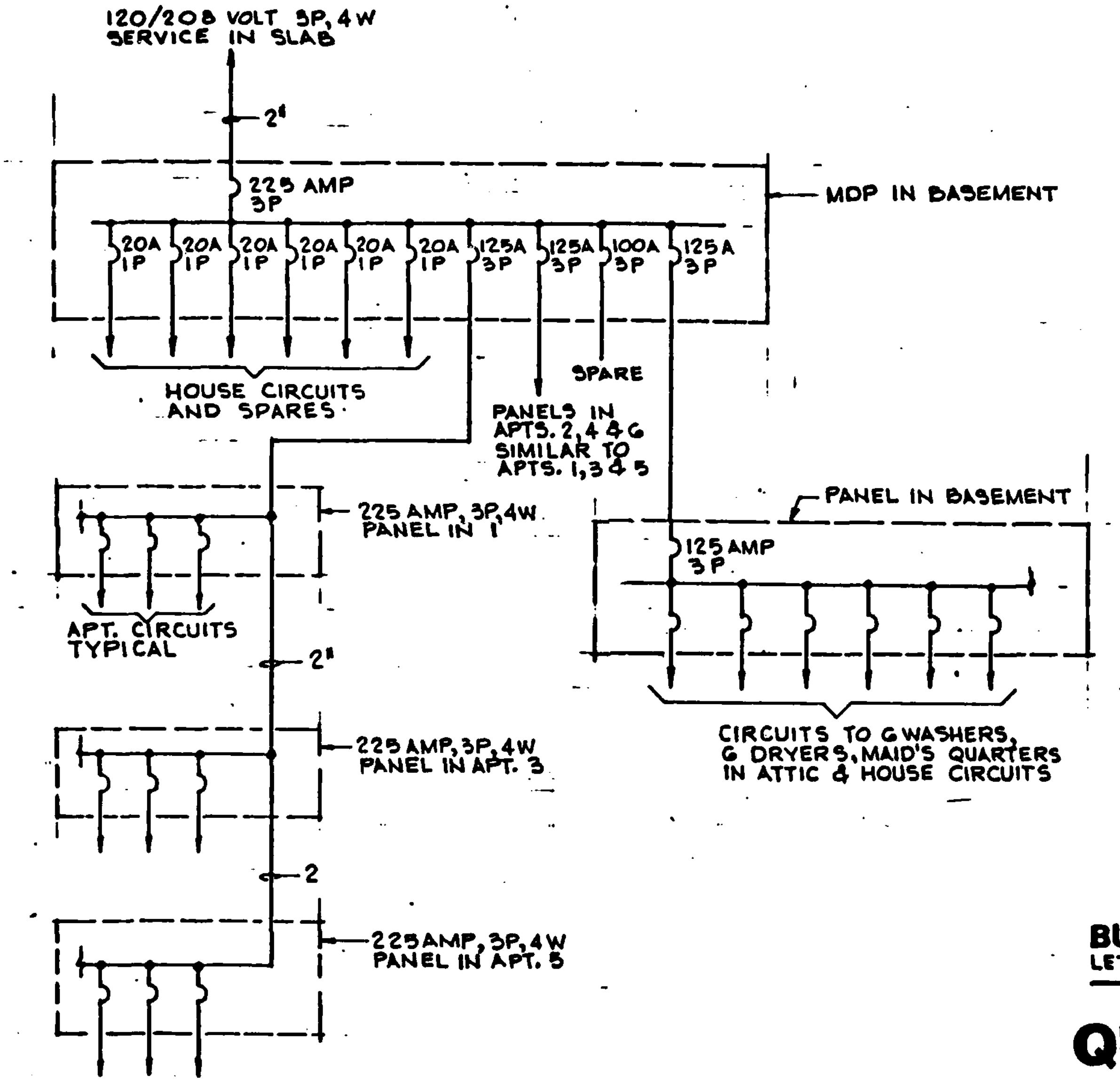
BUILDING TYPE:
LETTERED APTS.: F, G, H, I, K, N & O

QUANTICO METER STUDY

PLAN NTS

SKETCH NUMBER: 4

GAUTHIER, ALVARADO & ASSOCIATES



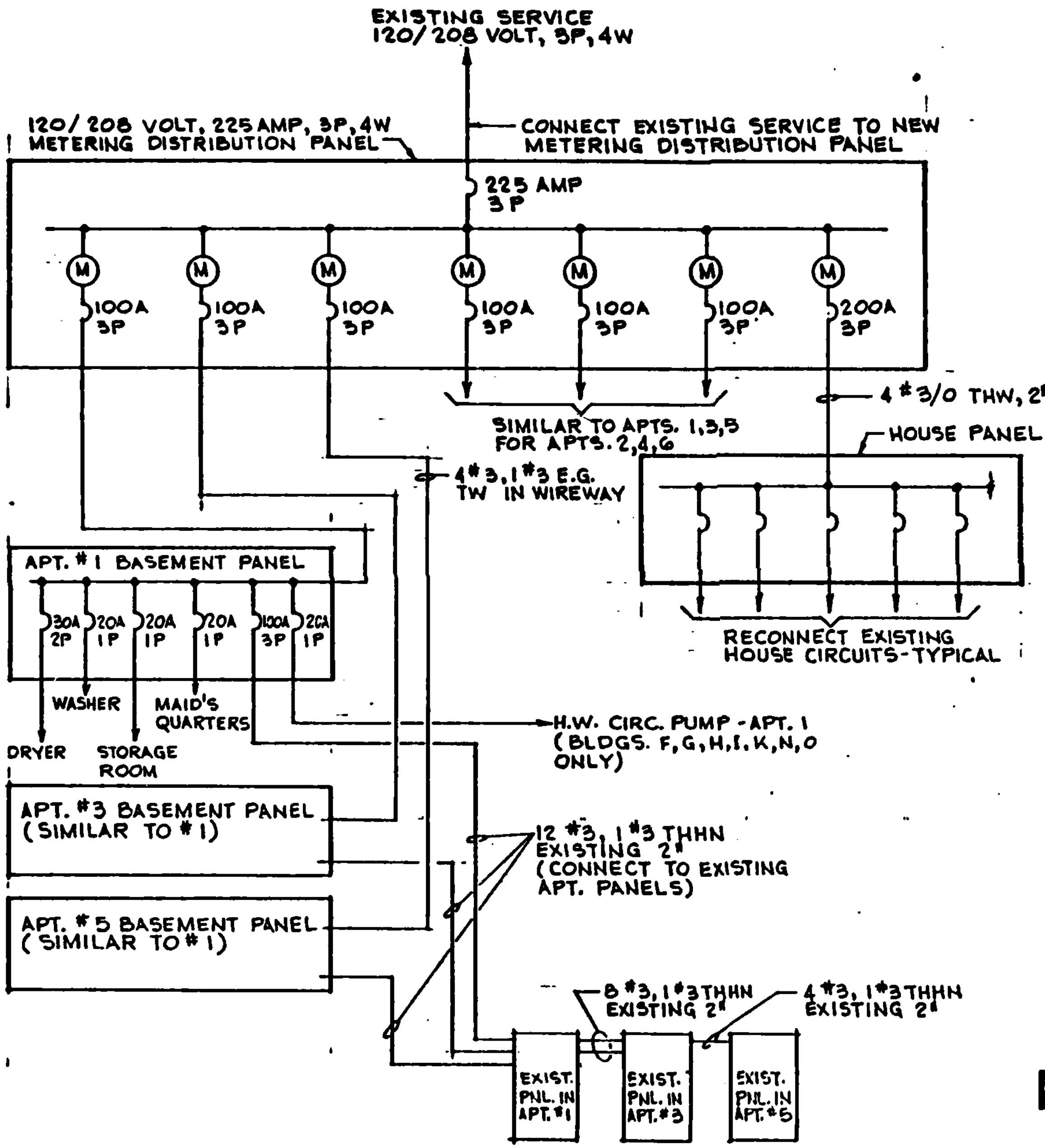
BUILDING TYPE:
LETTERED APARTMENTS

QUANTICO METER STUDY

EXISTING TYPICAL ELECTRICAL LINE DIAGRAM

SKETCH NUMBER: 5

GAUTHIER, ALVARADO & ASSOCIATES



NOTES:

1. REMOVE EXISTING MDP AND PANEL IN BASEMENT.
2. PULL NEW SEPARATE CIRCUITS TO EACH DRYER, WASH. MACH., STORAGE ROOM AND MAID'S QUARTERS.

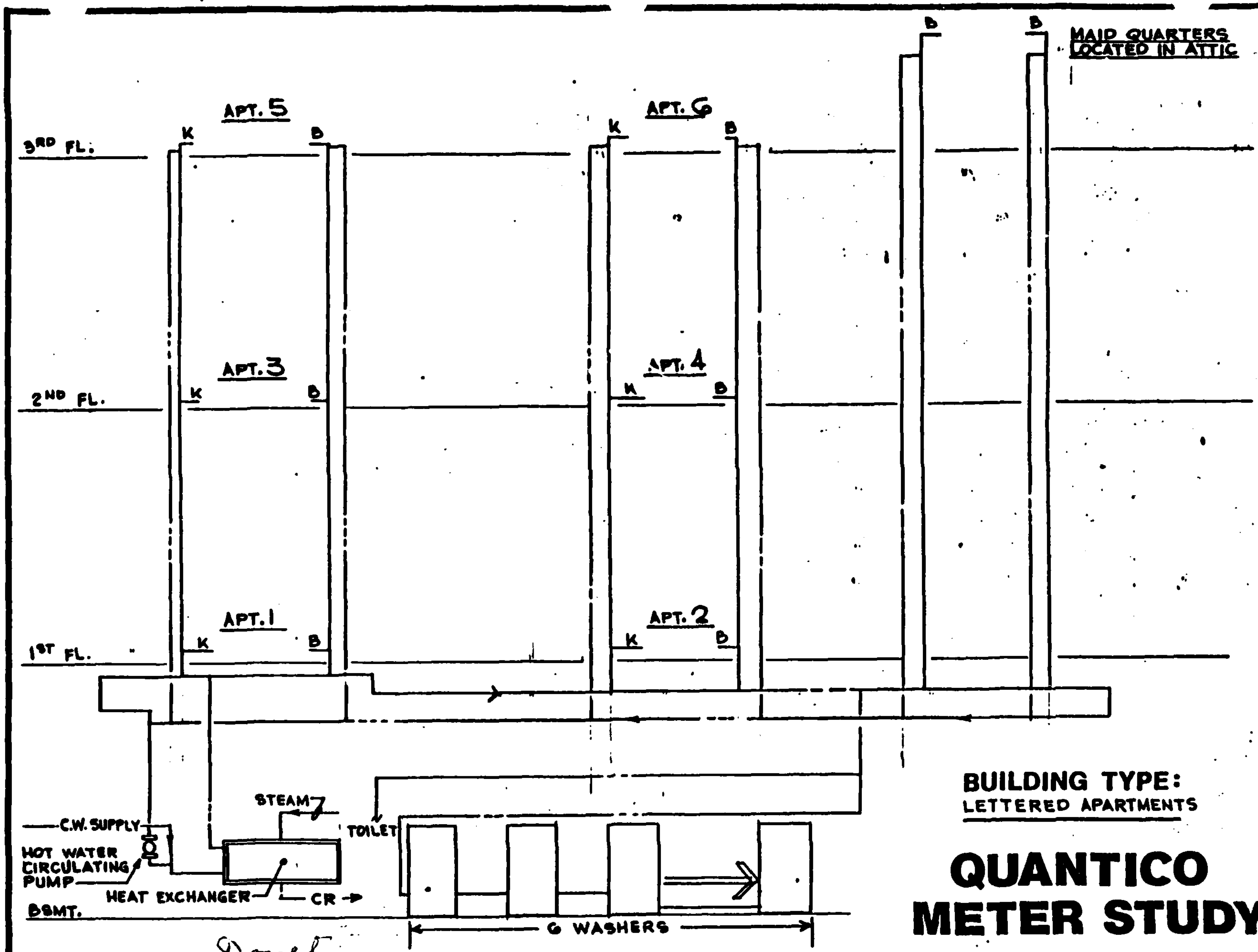
PROPOSED TYPICAL ELECTRICAL LINE DIAGRAM

BUILDING TYPE:
LETTERED APARTMENTS

QUANTICO METER STUDY

SKETCH NUMBER: 6

GAUTHIER, ALVARADO & ASSOCIATES



Domestic

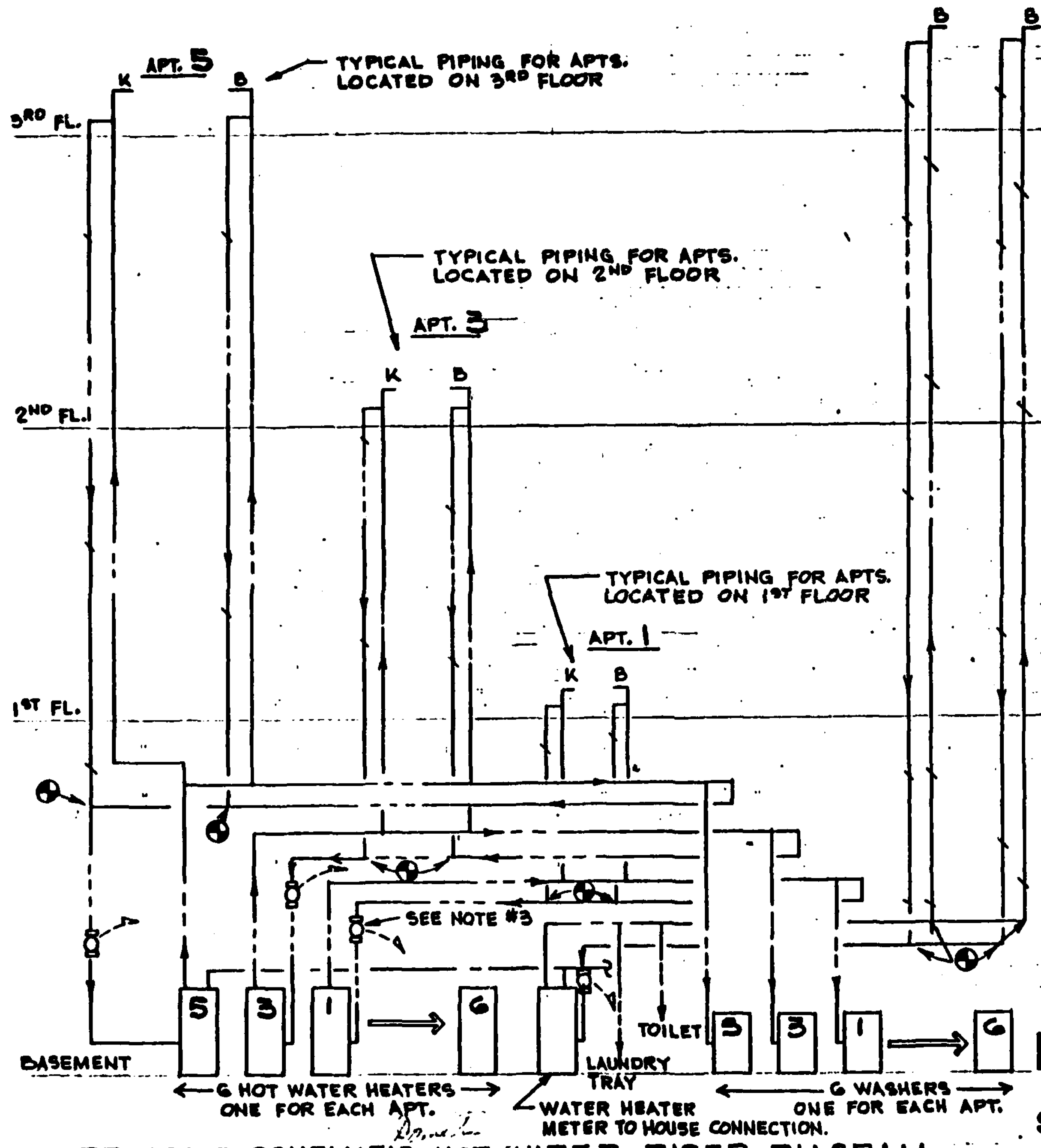
EXISTING HOT WATER RISER DIAGRAM NTS

BUILDING TYPE:
LETTERED APARTMENTS

QUANTICO METER STUDY

SKETCH NUMBER: 7

GAUTHIER, ALVARADO & ASSOCIATES



TOTAL NUMBER OF APTS. : 6

PLUS 6 MAID QUARTERS WITH 2 BATHROOMS

NOTES:

1. FOR STEAM SUPPLY & RETURN CONNECTIONS TO WATER HEATERS SEE SKETCH # 2
2. FOR LOCATION OF WATER HEATERS SEE SKETCH # 3
3. HOT WATER CIRCULATING PUMP. ONE REQ'D. FOR EACH APT. WIRE TO INDIVIDUAL ELEC. METERS.
4. FOR SYMBOLS SEE SKETCH # 1

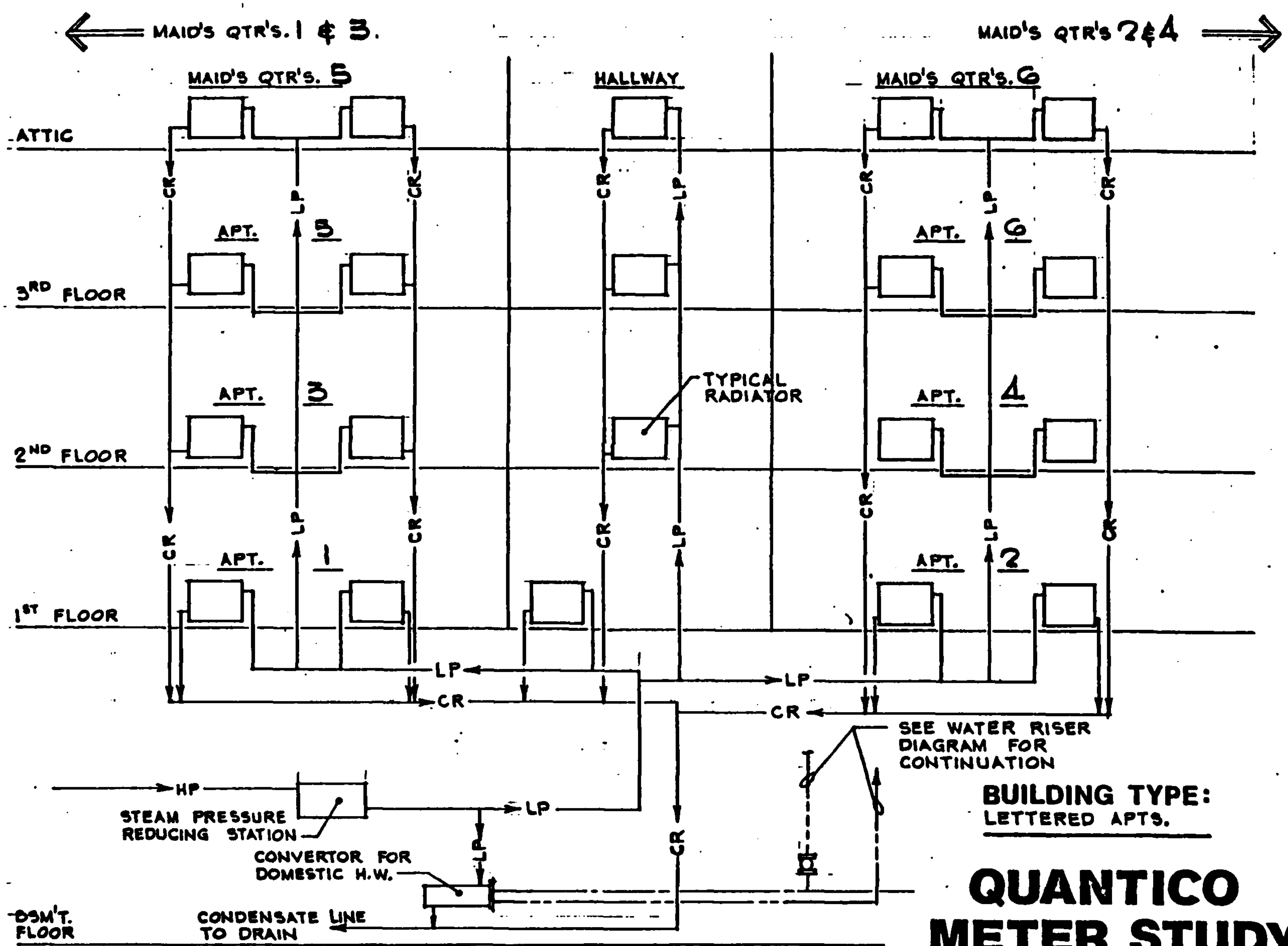
BUILDING TYPE:
LETTERED APARTMENTS

QUANTICO METER STUDY

SKETCH NUMBER: 8

PROPOSED SCHEMATIC HOT WATER RISER DIAGRAM

GAUTHIER, ALVARADO & ASSOCIATES



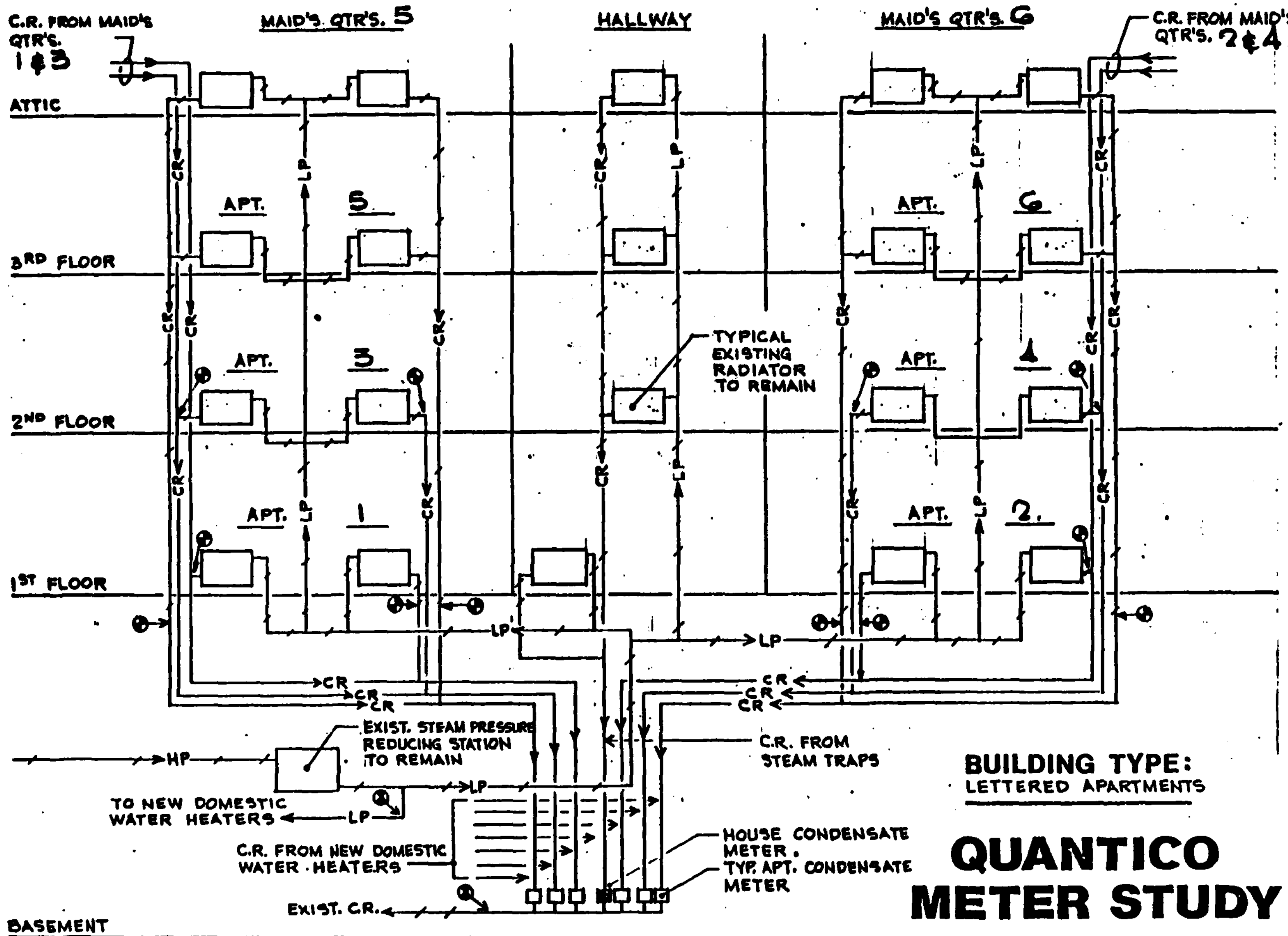
EXISTING STEAM HEAT RISER DIAGRAM

BUILDING TYPE: LETTERED APTS.

QUANTICO METER STUDY

SKETCH NUMBER: 9

GAUTHIER, ALVARADO & ASSOCIATES



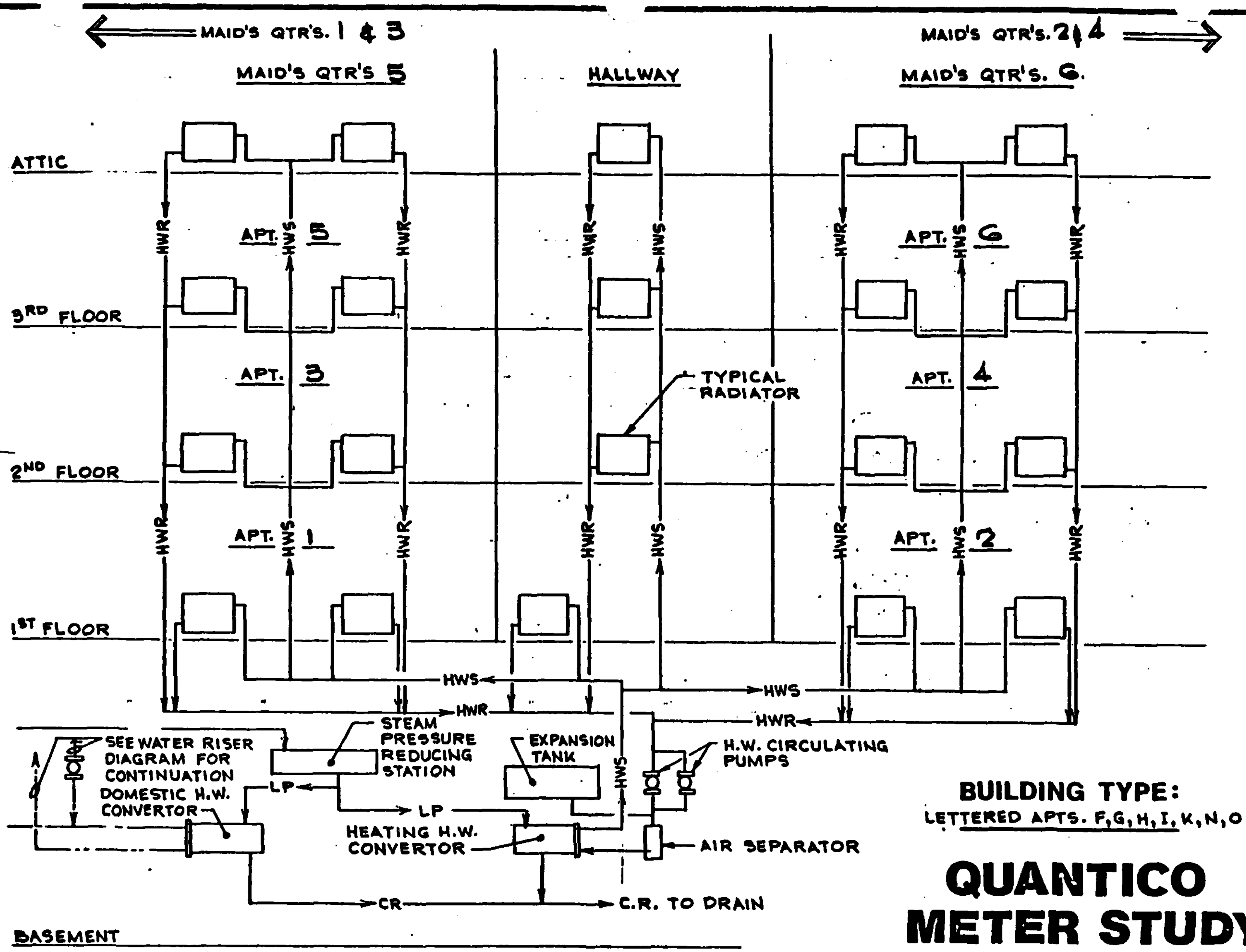
PROPOSED STEAM HEAT RISER DIAGRAM

BUILDING TYPE:
LETTERED APARTMENTS

QUANTICO METER STUDY

SKETCH NUMBER: 10

GAUTHIER, ALVARADO & ASSOCIATES



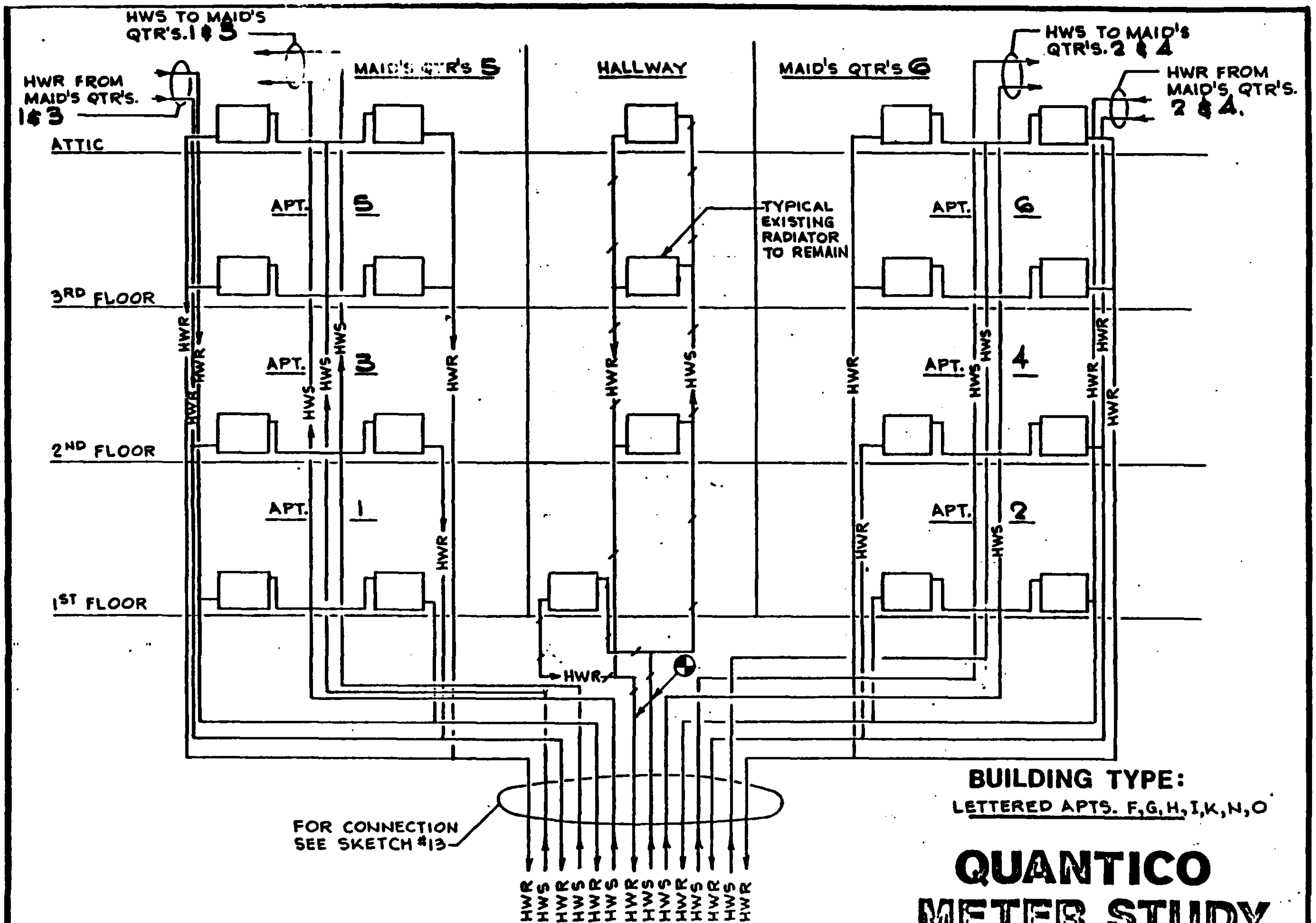
BUILDING TYPE:
LETTERED APTS. F, G, H, I, K, N, O

QUANTICO METER STUDY

EXISTING HOT WATER HEATING RISER DIAGRAM

SKETCH NUMBER: 11

GAUTHIER, ALVARADO & ASSOCIATES



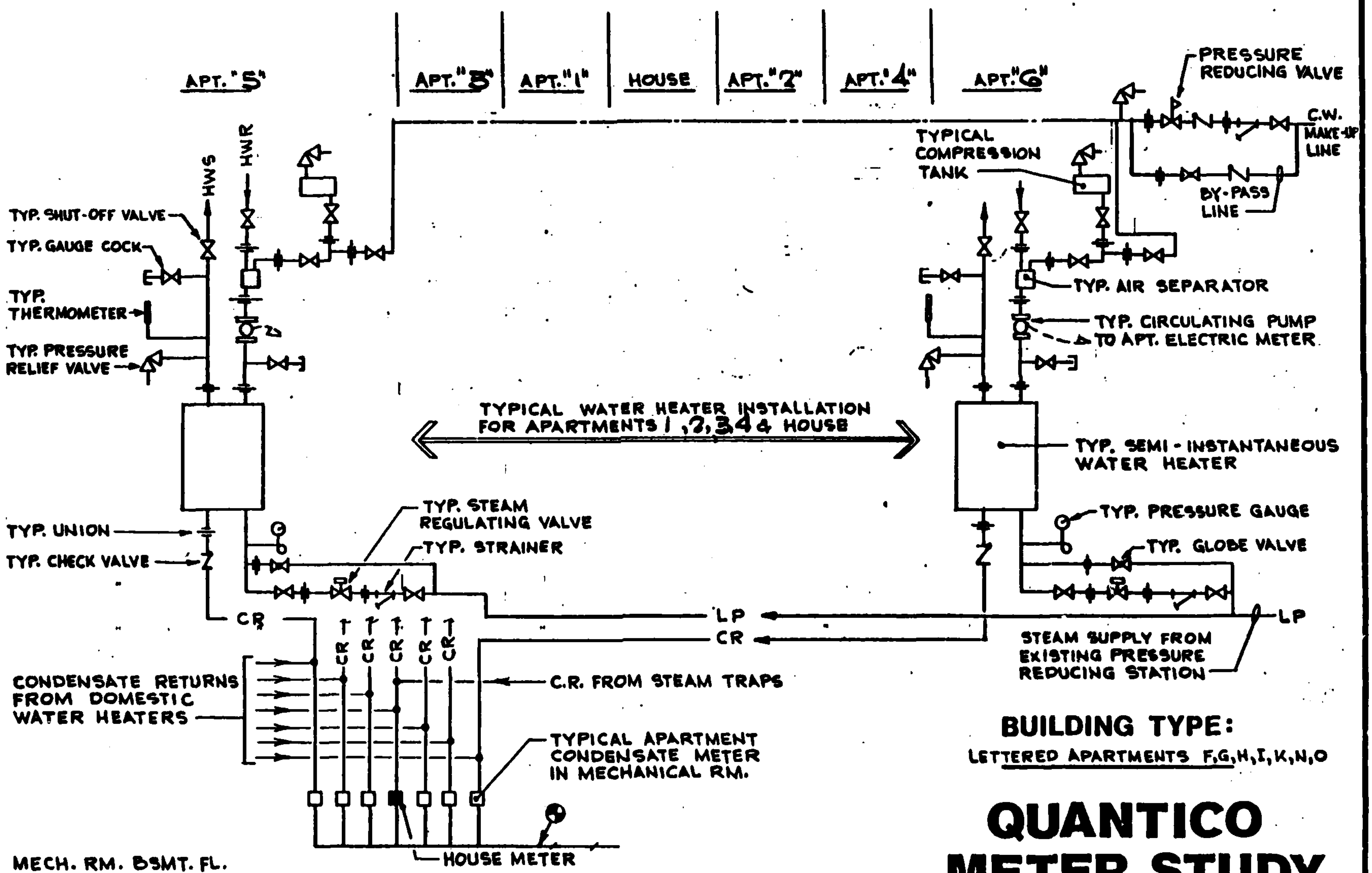
BUILDING TYPE:
LETTERED APTS. F, G, H, I, K, N, O

QUANTICO METER STUDY

PROPOSED HOT WATER HEATING RISER DIAGRAM

SKETCH NUMBER: 12

GAUTHIER, ALVARADO & ASSOCIATES



PROPOSED HOT WATER HEATING EQUIPMENT

BUILDING TYPE:

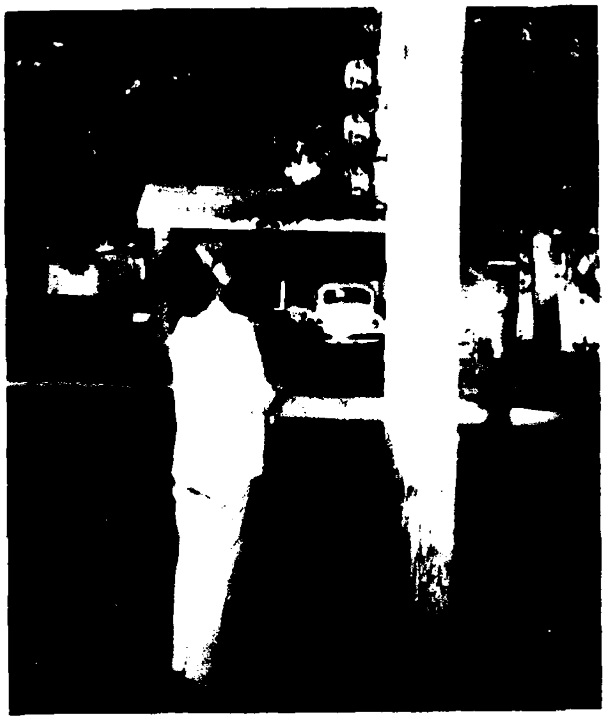
LETTERED APARTMENTS F,G,H,I,K,N,O

QUANTICO METER STUDY

SKETCH NUMBER: 13

GAUTHIER, ALVARADO & ASSOCIATES

METER READING PROBLEMS



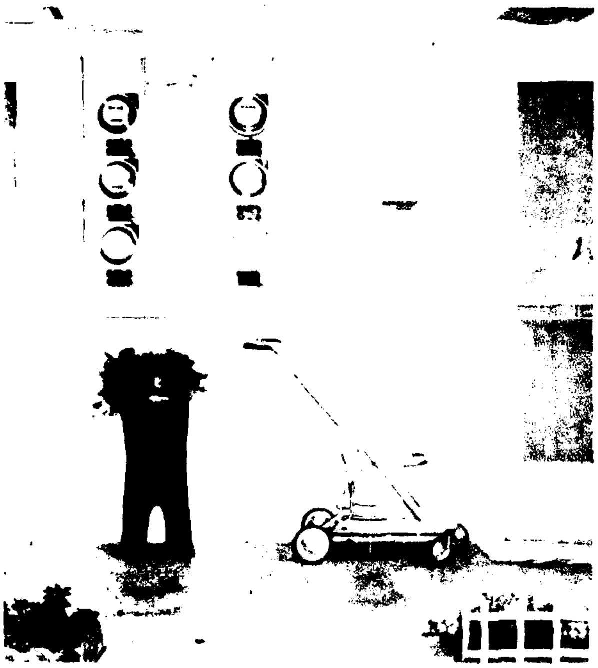
HIGH LOCATION

WHERE IS IT?

HAZARDOUS STEAM
METER LOCATION

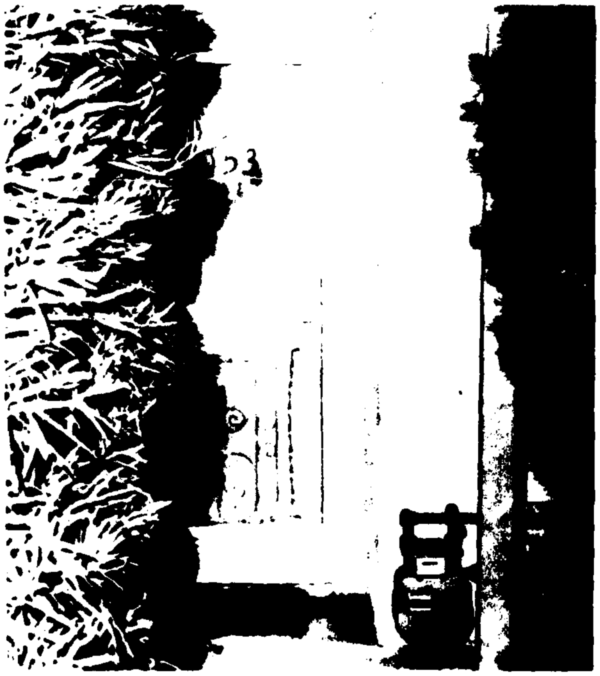
SELF EXPLANATORY

TYPICAL METER INSTALLATIONS

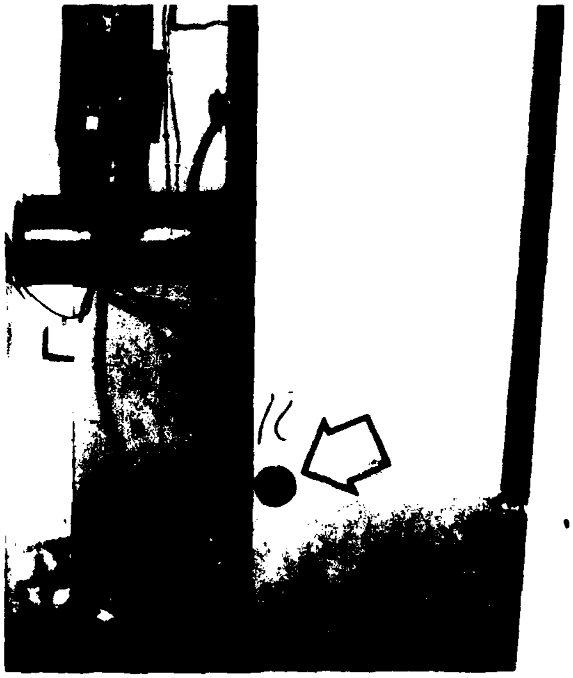


METERS FREQUENTLY AT FRONT DOOR BECAUSE SERVICE ENTRANCE IS IN FRONT

SEVERE DETRACTION FROM FRONT ENTRANCE



POOR GAS METER LOCATION



FUEL OIL METER INSIDE HOUSE

APPENDIX C : FAMILY HOUSING SURVEY

Building Number* ______________________________.

Building Group Number ________________________.

Installation ______________________________.

If Building is:

Group 3, fill out basic form (minus question 18) and fill out all required supplemental sheets.

Group 2, give building number of group 3 building which most closely typifies this buildings ______________.

Type of dwelling: ______________________________

Type of construction: ______________________________

and fill out questions 1 thru 18 of basic form including the calculation sheet for question 18.

Group 1 give building number of group 2 building which this building is identical to: ______________________. And fill out questions 1-17 of basic form.

* (one set of data is required for each family unit)

BASIC BUILDING SURVEY DATA

1. Installation:______________________
2. Activity Identifier Code: [ ][ ][ ][ ][ ][ ] 3 8

3. Building Number: [ ][ ][ ][ ][ ][ ] 9 14
4. Account Number: [ ][ ][ ][ ][ ][ ] 15 20

5. Address: [ ] 21 40

6. Number of Occupants: [ ][ ] 41 42
7. Number of Bedrooms: [ ] 43

8. Floor Area: [ ][ ][ ][ ] 44 47
9. Building Volume: [ ][ ][ ][ ][ ] 48 52

0. Window Area: [ ][ ][ ] 53 55

1. Domestic Water Heater Fuel: [ ] 56
   (G = Gas, E = Elect, O = Oil,
   S = Steam, H = Hot Water)
12. Cooking Fuel: [ ] 57
   (G = Gas, E = Elect)

3. Pilot Lights: (indicate number of Pilots, 0-9)
   a. Domestic Water Heater: [ ] 58
   b. Range: [ ] 59
   c. Clothes Dryer: [ ] 60
   d. Furnace: [ ] 61
   e. Air Conditioner: [ ] 62

4. Heating System:
   a. Fuel: (G = Gas, E = Elect, O = Oil, S = Steam, H = Hot Water) [ ] 63
   b. Type: Forced Air_____, Baseboard_____, Convector_____, Radiator_____
   c. Output Capacity:____________________Btu/hr
   d. Age:________Years

5. Cooling System:
   a. Fuel: (G = Gas, E = Elect, O = Oil, S = Steam, H = Hot Water, C = Chilled Water) [ ] 64
   b. Type: Central Air_____, Window Units_____, Evaporative Cooling_____
   c. Number of Units:________
   d. Capacity and Age of Each Unit:
      1)____________________Btu/hr ________Years
      2)____________________ ________
      3)____________________ ________

Activity Identifier Code ☐☐☐☐☐☐

Building Number ☐☐☐☐☐☐

Account Number ☐☐☐☐☐☐

6. List all common energy consuming devices outside the dwelling which are to be billed to the occupant and estimate their daily consumption.

a. Electrical (KWH)

Total ☐☐☐ (21–23)

b. Gas (Btu's)

Total ☐☐☐☐☐☐ (24–29)

c. Oil (Btu's)

Total ☐☐☐☐☐☐ (30–35)

d. Steam (Btu's)

Total ☐☐☐☐☐☐ (36–41)

e. Hot Water (Btu's)

Total ☐☐☐☐☐☐ (42–47)

f. Chilled Water (Btu's)

Total ☐☐☐☐☐☐ (48–53)

7. General Building Description:

a. Construction Type: ☐ 54
(C = Precast Concrete, F = Frame, B = Brick/Block, M = Masonry, O = Brick/Frame, S = Steel

b. Year structure was built: ☐☐ 55–56

c. Has building been weatherstripped and caulked: (Y = Yes, N = No) ☐ 57

d. Does structure have storm windows/doors: (Y = Yes, N = No) ☐ 58

e. Type of Dwelling: ☐ 59
(S = Single Family, D = Duplex, T = Townhouse, O = Other [Specify])

f. If more than two family, is unit: ☐ 60
(E = End Unit, C = Center Unit)

g. Is unit (T = top floor, M = middle floor, L = lowest floor) ☐ 61

h. Number of stories ☐ 62

i. Indicate basement, crawl space, or slab: ☐ 63
(B = Basement, C = Crawl Space, S = Slab)

j. Is there an attic: (Y = Yes, N = No) ☐ 64

18. Calculation of U-factor/Infiltration constant (A) U-factor (use attached calculation sheet)

a. Identify all thermodynamically unique sections of the external shell except surfaces in contact with the earth.

Examples: Walls: All external walls differing composition.

Roof : All roof sections of differing composition (not considered if building has ventilated attic)

Windows: All areas of differing composition.

Doors: All different constructions of doors.

Floors: All floor sections of different composition elevated above grade (exposed to outside air)

Ceiling : All ceiling sections of different composition-below unheated/cooled space (exposed to outside air) .

b. Calculate the area (ft^2) of each unique section of the external shell.

c. For each unique section, calculate the total thermal resistance as follows:

$$R_{total} = R_{inside\ film} + R_1 + R_2 + \ldots + R_{outside\ film}$$

(Values for R_1, R_2, can be obtained from ASHRAE Handbook of Fundamentals Chapter 20. Use .68 for $R_{inside\ film}$ and .17 for $R_{outside\ film}$.

d. Calculate the "U" factor for each unique section: $U = \dfrac{1}{R_{total}}$.

e. For each unique section multiply the U factor of that section by the area of that section.

f. Sum the UA products of every unique section comprising the external shell of the structure.

g. Calculate the air change rate:

$$ACR = \left[.59 + (.044)(\%\ WA) - \frac{(\%\ WA)^2}{3375}\right](f_s)(f_w)$$

Where: % WA = total window area divided by total wall area times 100.

f_s = .82 with storm doors and storm windows, 1.0 otherwise.

f_w = .82 with weatherstripping and caulking, 1.0 otherwise.

h. Calculate A:

$$A = 24\,(UA) + (.432)\,(ACR)\,(VOL)$$ ________.

18. (cont.)

UA Calculation Sheet

SECTION 1	MATERIALS	R VALUES	$U = 1/R_{tot}$	AREA	U X A
WALL 1					
WALL 2					
WALL 3					
WALL 4					
FLOOR					
ROOF/CEILING					
DOORS					
WINDOWS					
OTHER					

Sum of U X A = ________
(UA)

19. DETAILED BUILDING DESCRIPTION

a. Sketch Floor Plan, Show Exterior Walls and Dimensions

(Show True North On Plan)

19. DETAILED BUILDING DESCRIPTION (CONTINUED)

b. Determine length of interior partitions or show partitions and dimensions on floor plan ______________________________

c. Describe construction of interior partitions:

d. Number each exterior wall starting with most north facing and going clockwise around floor plan.

e. For each exterior wall, fill out a wall sheet.

f. Fill out ceiling/roof* Description sheet (s).

g. Fill out a floor description sheet (s) for each floor.*

h. Provide a Polaroid photograph of the buildings front and side elevations.

*The floor/ceiling between floor in Multi-Story Homes is considered a floor.

EXTERIOR WALL DESCRIPTION

a. Installation

b. Building No.

c. Wall No.

d. Sketch and dimension elevations of each wall (looking from exterior). Show location and number of windows and doors. Show shading devices used on windows and their dimension (include distance out from wall). Show entire wall from basement to roof and indicate where types of construction changes.

e. What type space is outside wall ☐ Earth ___ FT up Wall

☐ Outside ☐ Another living space ☐ Other ________________.

f. Detail Wall Description

Describe wall construction by layers starting with outside layer and working inward using materials from table 3 and showing thickness of each layer.* Repeat for each construction type used in wall.

LAYER	MATERIAL	THICKNESS (in.)

g. Number windows and describe construction using description from Table 1.

WINDOW	DESCRIPTION	FRAME MATERIAL

*For multimaterial layers such as studs with insulation, air space would be used.

h. Number doors and describe construction using description from Table 2.

DOOR	DESCRIPTION

FLOOR DESCRIPTION

a. Installation:

b. Building No.

c. What is under floor ☐ Living Space ☐ Ground

☐ Crawl Space ☐ Basement ☐ Other ________________.

If floor covers two of above, do separate descriptions for each section, show section on floor plan.

d. If basement is conditioned, then basement floor and walls must be described using appropriate wall description and a floor description.

e. Describe floor construction by layers starting with outside layer and working inward using materials from Table 3 and showing thickness.

LAYER #	MATERIAL	THICKNESS (IN.)

ROOF/CEILING DESCRIPTION

a. Installation:

b. Building:

c. Describe ceiling construction by layers starting with outside layer and working inward using material from Table 3 and showing thickness.

LAYER #	MATERIAL	THICKNESS(IN.)

d. What is above ceiling? ☐ OUTSIDE ☐ ATTIC

☐ LIVING SPACE ☐ OTHER ________________________.

e. If attic is checked, fill in attic/roof description sheet.

1 AUGUST 1978

DRAFT

FAMILY HOUSING MOCK UTILITY BILLING SYSTEM

USER MANUAL

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

200 STOVALL STREET
ALEXANDRIA, VA. 22332

TABLE OF CONTENTS

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APPENDICES

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Section 1. General.

1.1 Purpose of the User Manual. The purpose of the User Manual for the Family Housing Mock Utility Billing System (FH/MUBS) is to provide users of the system with an authoritative reference that will provide an overview of the system, the rules for its proper use, and a description of special operating constraints and capabilities.

1.2 Project Background. In a report to the 95th Congress, the General Accounting Office (GAO) stated that occupants of military family housing were consuming 30-50% more energy than residents of similar housing in the private sector. As a result, congress has enacted legislation calling for the installation of utility meters and establishment of a system to bill the residents for overconsumption of energy. To determine to what extent these households are overconsuming energy, an estimate of reasonable energy consumption (Norm) will be computed for each unit, based on the type of unit and the environmental conditions present. When the billing system becomes operational, each household will be charged for the amount of energy that they consumed over their norm.

1.2.1 In order to determine the feasibility of this system it will be tested before implementation takes place. During this period the test populations will receive a mock bill for the amount of energy which they consumed over their estimate, but will not be required to pay for this excess.

1.2.2 In order to comply with the congressional guideline that the test cover a representative cross section of the various climatic zones, the following ten activities were selected to participate in the test:

PWC Great Lakes, Illinois
CBC Port Hueneme, California
PMTC Point Mugu, California
MCDEC Quantico, Virginia
Fort Eustis, Virginia
Fort Gordon, Georgia
MCAS Beaufort, South Carolina
Little Rock AFB, Arkansas
Cannon AFB, New Mexico
Yuma Proving Grounds, Arizona

1.2.3 The systems manager for the FH/MUBS is the Naval Facilities Engineering Command (NAVFAC), 200 Stovall Street, Alexandria, Virginia 22332. Any questions regarding specific data processing procedures should be addressed to Ms. Marrea Riggs, Systems Division, autovon 221-8571, or commercial (202) 325-8571. Written suggestions and comments relating to the utility metering program, in whole or part, should be sent to this command, attention Code 082.

Section 2. Systems Summary.

2.1 Purpose. The purpose of the FH/MUBS is to perform the following functions:

a. take thermodynamic, weather, and occupancy data, edit the data, and compute a norm for the billing period,

b. take utility meter readings, edit the data, and calculate the actual consumption,

c. compare the norm with the actual consumption and produce bills for each occupant based on the excess consumption, and

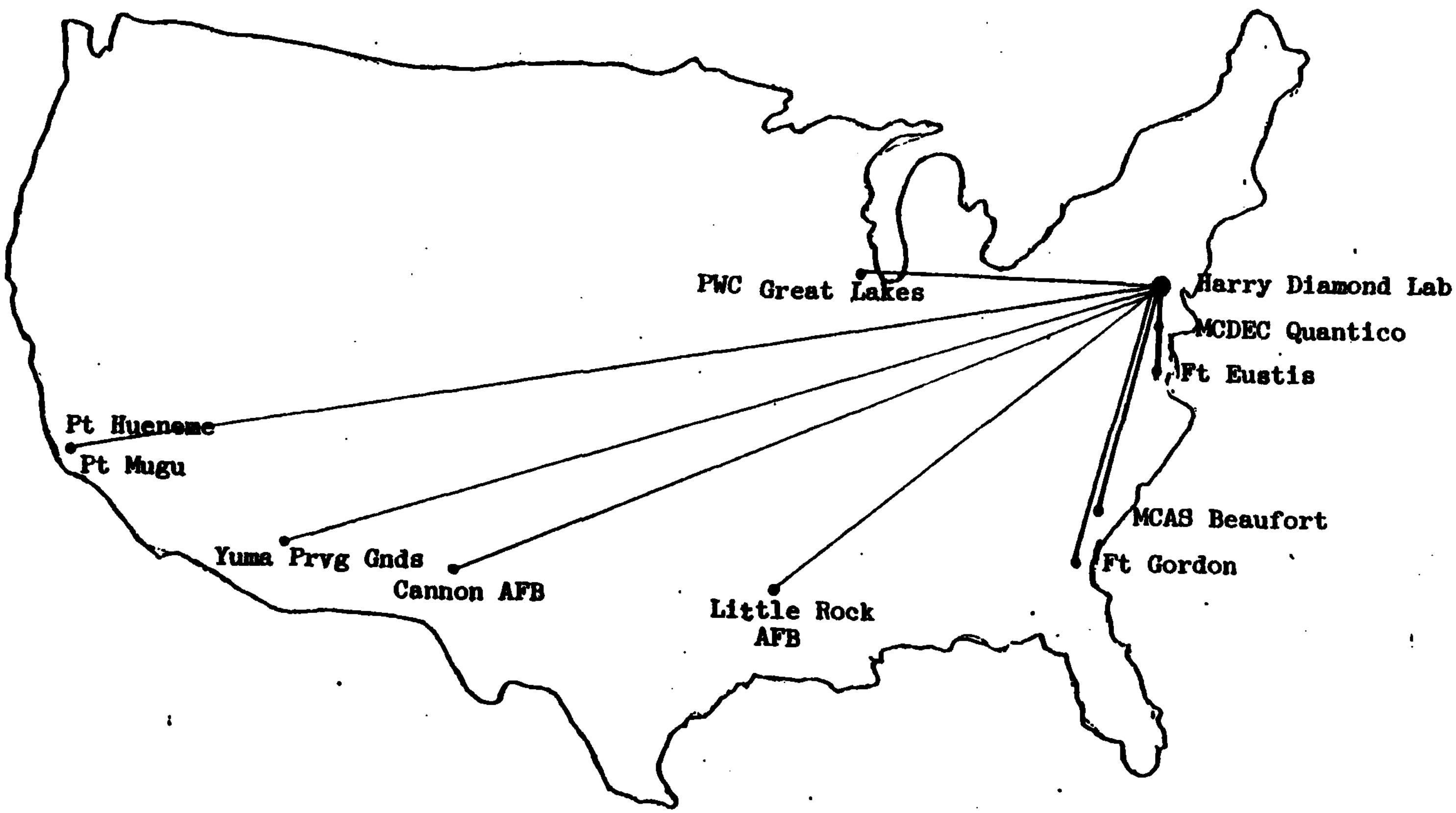
d. accumulate consumption and revenue data for management and statistical reports.

2.2 System Configuration.

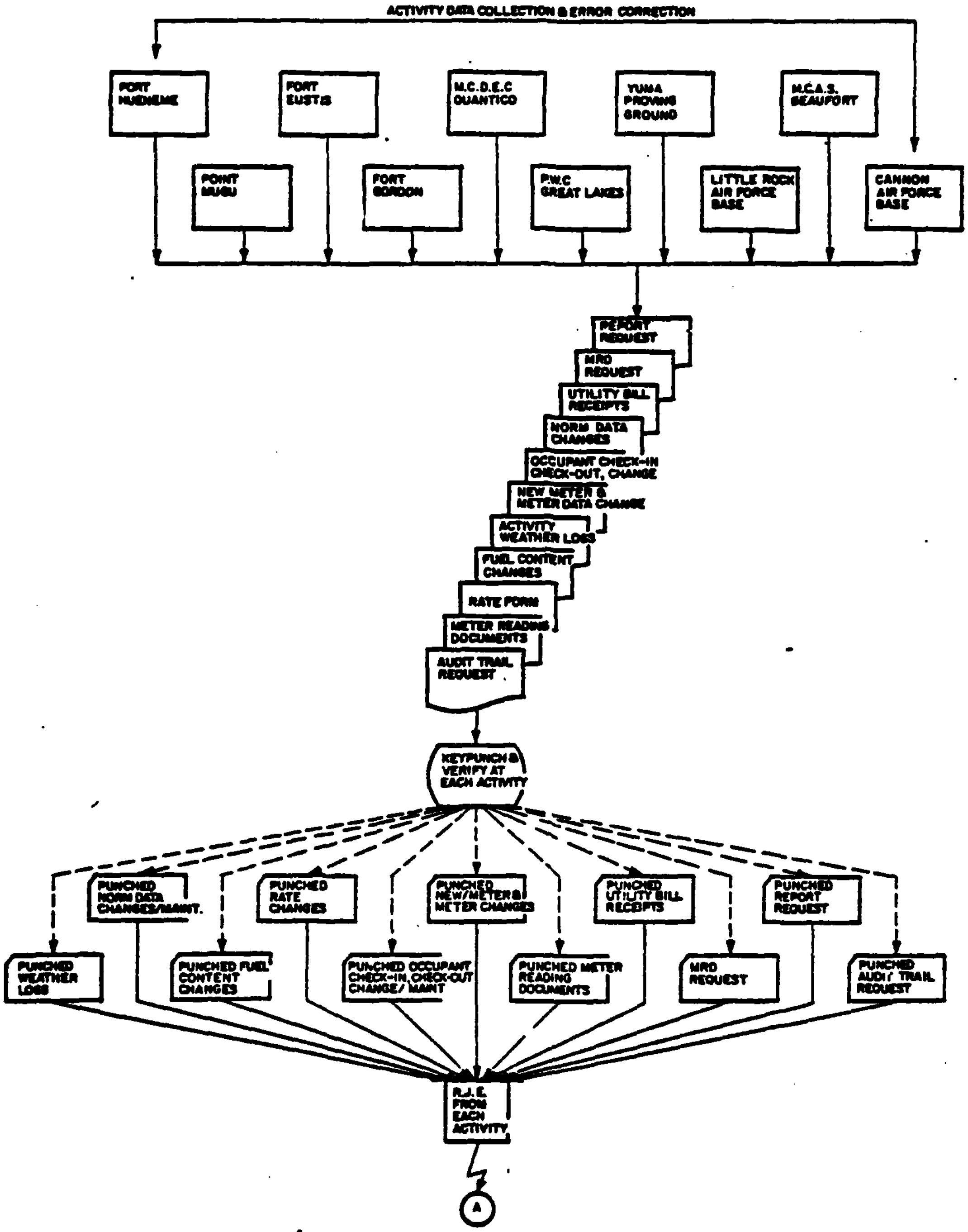
2.2.1 Hardware Environment. The FH/MUBS will be processed on an IBM 370/168 computer. Input will be by remote batch terminal.

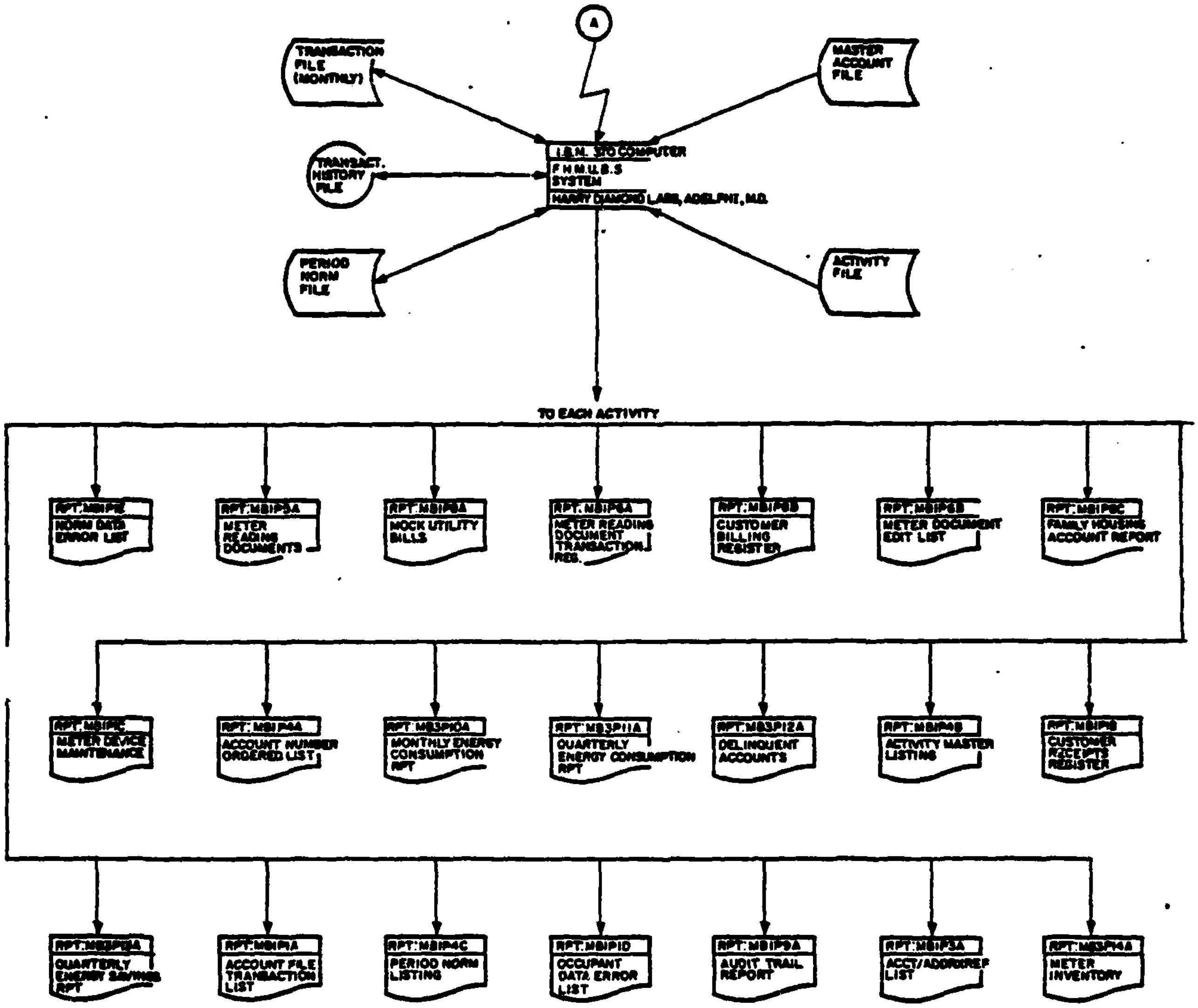
2.2.2 Software Environment. The system will consist of utility sorts, utility file backups, and ANSI COBOL program elements.

2.3 SYSTEM PROCF 'G NETWORK



SECTION 3. FH/MUB SYSTEM FLOWCHART




A
TRANSACTION FILE (MONTHLY)
MASTER ACCOUNT FILE
TRANSACT. HISTORY FILE
I.B.M. 370 COMPUTER
F H M U B S SYSTEM
HARRY DIAMOND LABS, ADELPHI, MD.
PERIOD NORM FILE
ACTIVITY FILE
TO EACH ACTIVITY
NORM DATA ERROR LIST
METER READING DOCUMENTS
MOCK UTILITY BILLS
METER READING DOCUMENT TRANSACTION REG.
CUSTOMER BILLING REGISTER
METER DOCUMENT EDIT LIST
FAMILY HOUSING ACCOUNT REPORT
METER DEVICE MAINTENANCE
ACCOUNT NUMBER ORDERED LIST
RPT:MB3P10A
MONTHLY ENERGY CONSUMPTION RPT
RPT:MB3P11A
QUARTERLY ENERGY CONSUMPTION RPT
RPT:MB3P12A
DELINQUENT ACCOUNTS
ACTIVITY MASTER LISTING
CUSTOMER RECEIPTS REGISTER
QUARTERLY ENERGY SAVINGS RPT
ACCOUNT FILE TRANSACTION LIST
RPT:MB1P4C
PERIOD NORM LISTING
RPT:MB1P1D
OCCUPANT DATA ERROR LIST
AUDIT TRAIL REPORT
ACCT/ADDR/XREF LIST
METER INVENTORY

4. System Documents.

4.1 Input Documents. This section describes documents that are used to submit data to the system. A transaction matrix at Appendix G shows all the system input transactions and the reports on which they appear.

4.1.1 Activity Weather Log. The purpose of this form is to collect the daily air and water temperatures that are used to compute energy consumption norms. An example of an Activity Weather Log is at Appendix C.1.*

4.1.2 Norm Data Changes/Corrections Form. The purpose of this form is to change or correct data pertaining to energy consumption norms. Only certain data elements may be changed/corrected with this form (see Section 5, paragraph 5.3, "Processing Norm Data"). An example of a Norm Data Changes/Corrections Form is at Appendix C.2.

4.1.3 FH/MUBS Fuel Content Changes. The purpose of this form is to collect the B.t.u. content for natural gas, oil, and propane gas at an installation. Norms are first computed in B.t.u.'s, then converted into the standard unit of measure for an energy source based on the fuel content data. An example of a FH/MUBS Fuel Content Changes Form is at Appendix C.3.

4.1.4 FH/MUBS Rate Form. The purpose of this form is to collect/change utility rates at an activity. An example of a FH/MUBS Rate Form is at Appendix C.4.

4.1.5 FH/MUB Occupant Check-in Sheet. The purpose of this form is to collect data on new occupants which will be used to trigger the FH/MUBS to adjust the norm data on the master file and to send the mock utility bill to the proper occupant. An example of a FH/MUB Occupant Check-in Sheet is at Appendix C.5.

4.1.6 FH/MUB Occupant Data Change/Maintenance form. The purpose of this form is to change occupant data and correct errors detected when the FH/MUB Check-in, Check-out, and Change/Maintenance sheets are submitted. An example of a FH/MUB Occupant Data Change/Maintenance form is at Appendix C.6.

*Instructions for completing all input forms are provided on the reverse of the forms.

4.1.7 FH/MUB Occupant Check-out Sheet. The purpose of this form is to notify the system when a housing unit is vacated and collect a forwarding address for the occupant. An example of a FH/MUB Occupant Check-out Sheet is at Appendix C.7.

4.1.8 Family Housing Mock Billing New Meter Data Form. The purpose of this form is to collect data pertaining to the physical characteristics of a meter when a new meter number is created. An example of this form is at Appendix C.8.

4.1.9 Family Housing Mock Billing Meter Data Change Form. The purpose of this form is to change/correct data pertaining to an existing meter number. An example of this form is at Appendix C.9.

4.1.10 Input/Output Documents. In two cases, the FH/MUBS generates an output document which is later used as an input document.

a. Meter Reading Document. After a meter reading document has been completed, the document is used as a source document for keypunching. The format of the keypunched meter reading document is at Appendix C.10.

b. Utility Bill Receipts. When a Mock Utility Bill is sent to an occupant if a balance appears on line 12 of the bill, the stub (i.e. receipt) is returned to the housing office as "payment" of the bill. The format of the keypunched utility bill receipt is at Appendix C.11.

4.1.11 Control and Document Request Forms. Several reports in the system are produced on request from the user. This section describes the documents required to request the user-generated system reports. An example of these forms, with detailed instructions, is provided in Appendix C..

a. Audit Trail Request. This form is used to request the Audit Trail Report (Report No. MB1P9-A). See Appendix C.12 for an example of this form and Appendix E.12 for keypunching instructions.

b. Meter Reading Document Request Form. This form is used to request preprinted and blank meter reading documents. See Appendix C.13 for an example of this form and Appendix E.13 for keypunching instructions.

c. FH/MUBS Report Request. This form is used to request the following reports:

FH/MUBS Account Number Ordered Listing
(Report No. MB1P4-A).
FH/MUBS Activity Master Listing
(Report No. MB1P4-B).
Account Number/Address Cross Reference List
(Report No. MB1P3-A).
Period Norm Listing
(Report No. MB1P4-D).

See Appendix C.14 for an example of this form and Appendix E.14 for keypunching instructions.

4.2 Output Documents. All documents described in this section are produced at the activity detail level.

4.2.1 Meter Reading Documents (MRDs). A MRD is used to collect readings on the metering devices at each service location. These documents are computer generated upon request from the user except when a meter reading is rejected and the system automatically generates a replacement MRD. See paragraph 4.1.11b for an explanation of how to request MRDs and Appendix D.1 for sample MRDs.

4.2.2 Meter Reading Document Transaction Register (Report No. MB1P6-A). The Meter Reading Document Transaction Register is produced when completed meter reading documents ('MR' transactions) are keypunched and submitted through the remote job entry station to the central processing site. The report shows all meter readings submitted, listed by meter number within account number. MRD transactions will appear in punched card format with spaces inserted between fields for legibility. At the end of the report totals are given for: the number of accounts for which meter readings were taken, the number of meters at those accounts, the number of meters actually read, and the number of missing meter readings. See Appendix D.2 for an example of this report.

4.2.3 Meter Document Edit List (Report No. MB1P6-B). Rejected meter reading document transactions are shown on this report which is generated when meter readings ("MR" type transactions) are submitted to the system. MRD transactions are shown in punched card format with a space inserted between fields for legibility. Error messages precede each transaction, corresponding to pointers indicating the field in error. See Appendix D.3 for an example of this report.

4.2.4 Customer Receipts Register (Report No. MB1P1-B). This summary of utility bill receipts is produced when punched receipt stubs ("RR" type transactions) are submitted to the system. This report shows account number, occupant number, the billing date, and the amount of each receipt. A summary shows the total number of receipts received and the total "dollars" processed. See Appendix D.4 for an example of this report.

4.2.5 Account File Transaction List (Report No. MB1P1-A). All transactions submitted to the system, other than meter readings and control/document request cards, appear on this report which is generated each update cycle. Transactions are listed by transaction date and account number with spaces inserted between each field for legibility. See Appendix D.5 for an example of this report.

4.2.6 Meter Data Error List (Report No. MB1P1-C). Rejected new meter data and meter data change transactions ("Z" type transactions) are listed on this report which is generated each update cycle. Error messages precede each transaction corresponding to pointers indicating the field in error. See Appendix D.6 for an example of this report.

4.2.7 Occupant Data Error List (Report No. MB1P1-D). Rejected occupant check-in, check-out and data change/maintenance transactions ("D" type transactions) and rejected utility receipts ('RR' type transactions) are printed on this report produced each update cycle. Error messages precede each transaction corresponding to pointers indicating the data in error. See Appendix D.7 for an example of this report.

4.2.8 Mock Utility Bill (Report No. MB1P8-A). Mock Utility Bills are produced according to the schedule shown at Section 5, paragraph 5.1. The bill shows consumption and cost for each utility at a dwelling unit. New and previous readings, actual and norm usage and the difference between the two are shown. See Appendix D.8 for an example of the utility bill.

4.2.9 Customer Billing Register (Report No. MB1P8-B). The register is a recapitulation in account number sequence of the bills produced each cycle. The total variance charges, past due unpaid balance, and total amount billed are shown for each account number. Dollar amounts are summarized by utility type within occupant accounts, as well as a combined total of all accounts. Batch totals showing the number of customers billed are given. See Appendix D.9 for an example of this report.

4.2.10 Family Housing Account Report (Report No. MB1P8-C). Usage at vacant housing units and common usage locations is listed on this report which is generated each billing cycle. The cost of all usage charged to Family Housing is provided at the end of the report. See Appendix D.10 for an example of this report.

4.2.11 FH/MUBS Account Number Ordered Listing (Report No. MB1P4-A). This report lists structural, thermodynamic and occupant data collected from the housing surveys that are used to calculate norm consumption for a dwelling unit. Data are presented in account number sequence. This report is produced upon request from the user. See paragraph 4.1.11c for an explanation of how to request this report and Appendix D.11 for a sample report.

4.2.12 Norm Data Error List (Report No. MB1P1-E). Errors on fuel B.t.u. content (transaction type '63'), weather (transaction type '12' and '13') and norm data (transaction type ('31', '32', '33', '42', '52') transactions will appear on this report, which is produced each update cycle. Error messages precede each transaction corresponding to pointers indicating the field in error. See Appendix D.12 for an example of this report.

4.2.13 FH/MUBS Activity Master Listing (Report No. MB1P4-B). This report lists air and water temperatures (used to compute norm consumption), fuel B.t.u. content, and utility rates. It is printed upon request from the user. See paragraph 4.1.11c for an explanation of how to request this listing and Appendix D.13 for a sample report.

4.2.14 Account Number/Address Cross Reference List (Report No. MB1P3-A). This report provides a list of meter service addresses in account number sequence. It is produced upon request from the user. See paragraph 4.1.11c for an explanation of how to request this report and Appendix D.14 for a sample report.

4.2.15 Audit Trail Report (Report No. MB1P9-A). This report lists transactions according to parameters specified in a control card. It is produced upon request from the user. All transactions may be listed, or transactions for a particular account or range of accounts. A second parameter specifies a range of dates. Any combination of accounts or dates may be selected. A cover page shows a list of transaction codes. See paragraph 4.1.11a for an explanation of how to request this report and Appendix D.15 for a sample report.

4.2.16 Period Norm Listing (Report No. MB1P4-D). This report lists the system-computed norm consumption that was used for each account billed. It is produced upon request from the user. Each norm is listed, by account number. See paragraph 4.1.11c for an explanation of how to request this report and Appendix D.16 for a sample report.

4.2.17 Monthly Energy Consumption Report (Report No. MB3P10-A). This report lists, by category of quarters in account number sequence, the actual and norm usage for each utility at a unit. Variance from norm usage is shown and expressed in dollars saved or charged. An example of this report is provided at Appendix D.17.

AD-A081 057 OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE (--ETC F/G 13/1
FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
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4.2.18 Quarterly Energy Consumption Report (Report No. MB3P11-A). This quarterly report summarizes, by category of quarters and type of utility, actual and norm usage (and variance from the norm) for occupied units, actual consumption at vacant units, total consumption, and the total of occupied and vacant days. An example of this report is provided at Appendix D.18.

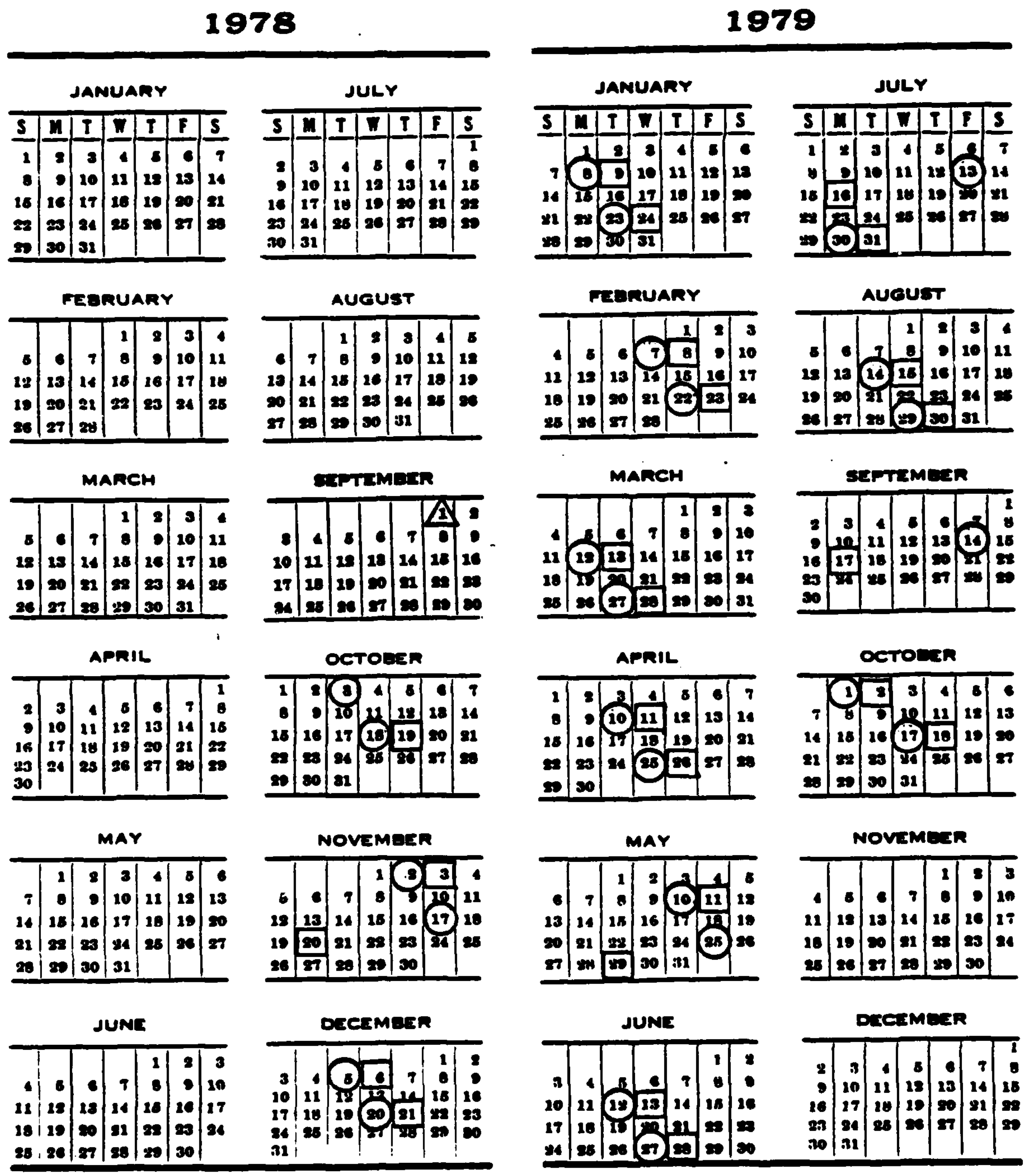
4.2.19 Delinquent Accounts (Report No. MB3P12-A). This report lists accounts 31 to 60, 61 to 90, and over 90 days delinquent in "payment" of utility bills. It is produced each billing cycle. An example of this report is provided at Appendix D.19.

4.2.20 Quarterly Energy Savings (Report No. MB3P13-A). This quarterly report lists, by category of quarters and utility type, the number of incidents where consumption was within the norm and the amount of energy and dollars saved. An example of this report is provided at Appendix D.20.

4.2.21 Meter Inventory (Report No. MB3P14-A). This is a semi-annual report in meter serial number sequence showing the type of meter, the date the meter was received at an installation, and where the meter is located (i.e. on housing unit, in the repair shop, etc.). An example of this report is provided at Appendix D.21.

Section 5. System Operating Procedures.

5.1 System Operating Schedule. Data may be submitted to the billing system via a remote job entry station on any work-day between 0700 and 1830 Eastern time. Data which is accepted by the system and submitted prior to close of business on days in red circles (See below) will be reflected on the bills ready for printing on days in blue squares.



△ - FH/MUBS test begins

○ - Billing information processed

□ - Bills ready for printing

5.2 Processing Weather and Water Temperature Data.

5.2.1 Two types of information must be collected to calculate a norm for a family housing unit. First, there is data relating to the physical properties of the unit. Second, there is data on weather and water temperature.

5.2.2 Physical property data was collected during the housing surveys and remains relatively constant. Weather and water temperature data is collected daily for the duration of the FH/MUB test. See Appendix C.1 for an example of the Activity Weather Log.

5.2.3 Weather data must be entered into the system each billing cycle for every day covered by meter readings. If weather data is not available for any day of a billing cycle, no bills can be produced for accounts with meter readings that include any missing days.

5.2.4 A detailed schedule for data collection, input and billing cycles is provided in paragraph 5.1.

5.2.5 The Activity Weather Log must be keypunched according to the instructions at Appendix E.1. Use the Job Control deck at Appendix F.1. to submit punched weather data to the system via the remote job entry station.

5.3 Processing Norm Data.

5.3.1 Changing and validating the norm data collected on pages 2, 3, and 4 of the Basic Building Survey Data form (Appendix I) may be necessary because of keypunching or reporting errors. Transactions are also required to change the physical properties of a housing unit (e.g. adding insulation or storm windows) or the type of appliances in the unit (e.g. replacing a gas stove with an electric stove). The Norm Data Changes/Corrections Form at Appendix C.2 is used to make all norm data element changes and corrections on pages 2 and 3 except for data in items 14b and 15b, which were not entered into the master file. See paragraph 5.3.2 if changes are required to 14b or 15b. Items 14c, 14d, 15c, and 15d should not be corrected since they are no longer pertinent.

5.3.2 Several norm data elements from pages 2 and 3 of Appendix I have been used by the survey teams and by the Army's Construction Engineering Research Laboratory (CERL) to determine the data elements shown on page 4. Accordingly, changes to the following items must be submitted to the mechanical engineer designated by the Service Metering Task Force Representative for review and coordination with CERL to revise any other related data elements:

	Item #	Data Element
a.	9	Volume
b.	10	Window Area
c.	14a	Fuel-Heating
d.	14b	Heating System Type 1/
e.	15a	Fuel-Cooling 2/
f.	15b	Cooling System Type 1/ 2/
g.	17c	Weatherstripping
h.	17d	Stormproofing

1/ Not a FH/MUBS data element but essential for determining the data on page 4.

2/ No engineering review required for adding or deleting electric window air conditioners and electric or gas central air conditioning.

5.3.3 When a change listed in Section 5.3.2 is required, the following information must be provided to the designated mechanical engineer for recomputation and coordination with CERL before entering these changes to the system:

a. A list of account and building numbers involved, indicating the original Group 2 unit.

b. A copy of the original Group 2 calculation sheets along with the data being revised (required only if changing items 9,10,17c or 17d).

c. A copy of page 4, as completed by CERL, for the Group 2 unit (items 4-17 identical for related Group 1 units).

d. A brief statement of what caused the changes (e.g., no insulation in the exterior stucco walls vice 3" erroneously shown on the "as built" drawings).

e. The name(s) and phone number(s) of the person(s) to contact for further information or confirmation of the changes.

5.3.4 If changes to other than pages 2 or 3 are required to a Group 3 unit, submit a copy of the original Group 3 package, the necessary revised pages completed by an activity mechanical engineer, and a list of the related Group 2 building numbers.

5.3.5 A copy of the cover memorandum and the list of account and building numbers should also be forwarded to the Naval Construction Battalion Center, Facilities Systems Office, Code 18A8, Port Hueneme, CA ATTN: PRI Error Control Technician and to the Naval Facilities Engineering Command, 200 Stovall St., Alexandria, VA 22332, ATTN Code 0112D.

5.3.6 Upon completion of the review, the mechanical engineer will circle the revised entries on page 4, (items 4-17 for the Group 2 unit) and mail or transmit this data to NCBC Port Hueneme for processing, with an information copy to NAVFAC. A record copy of page 4, along with confirmed page changes to the Group 2 calculations or Group 3 package, will be forwarded to the activity. The activity must then enter the norm data changes from Section 5.3.2 for each account and building number.

5.3.7 Any norm data element on page 2 or 3 which was keypunched erroneously may be corrected without consulting the designated mechanical engineer. To correct keypunching errors on page 4, the activity must send a copy of the original page 4 to NCBC Port Hueneme circling the data to be corrected.

5.3.8 The Norm Data Changes/Corrections Form must be keypunched according to the instructions at Appendix E.2. Use the job control deck at Appendix F.1 to submit norm data changes to the system via the remote job entry station.

5.4 Generating Meter Reading Documents (MRDs).

a. MRDs may be requested at any time. The user is responsible for developing meter reading route and sequence numbers. The MRDs requested on the MRD Request Form will be available for printing on the remote site terminal on the working day following submission of the request (See Appendix C.13 for an example of the MRD request form).

b. MRD Request Forms must be keypunched according to the instructions at Appendix E.13. Use the Job Control deck at Appendix F.2 to submit punched MRD request cards to the system via the remote job entry station.

5.5 Processing Meter Reading Documents.

5.5.1 There are five conditions that require meters to be read:

a. The scheduled monthly reading.

(1) The Housing Office (or other designated office) will determine the monthly meter reading schedule. All meters will be read each month.

(2) Preprinted meter reading documents will be requested in accordance with the monthly reading schedule.

b. Occupant Check-in.

(1) All meters for a unit will be read at check-in.

(2) Meter reading documents with blank header data will be used.

c. Occupant Check-out.

(1) All meters for a unit will be read at check-out.

(2) Meter reading documents with blank header data will be used.

d. Corrected Reading.

(1) When one or more meter readings are rejected for a unit, all readings for that unit will be rejected.

(2) The computer will generate new meter reading documents.

(3) Header data will be preprinted except "To" block in Service Period.

e. Computation Reading.

(1) Some activities have units which share a common energy source monitored by a master meter. These units must have a ratio computed to determine actual consumption. Whenever an occupant checks in or out of one of

these units, the master meter as well as meters for all the other units sharing the common energy source must be read in order to calculate the proper ratio. Failure to read all meters will cause rejection of all associated transactions.

(2) The meter reading document will be computer generated.

(3) Documents with blank header data will be used.

5.5.2 Examples of Meter Reading Documents are provided at Appendix D.1.

5.5.3 Meter Reading Documents must be punched according to the instruction at Appendix E.10. The Job Control deck at Appendix F.3 must be used to submit punched meter readings to the system via the remote job entry station.

5.6 Processing an Occupant Check-in.

5.6.1 When a housing unit becomes occupied a FH/MUB Occupant Check-in Sheet must be filled out and meter readings taken for all meters at the unit. The completed Check-in Sheet and meter reading documents should be submitted for keypunching and entered to the system as soon as possible.

5.6.2 It should be noted that there is no occupant number on the FH/MUB Occupant Check-in Sheet. The computer will automatically assign this number and print it out on the Account File Transaction List. Check-in transactions can be identified by the characters "D2" in the first two print positions of the first card and "D3" in the first two print positions of the second and third cards.

5.6.3 Occupant Check-in Sheets must be keypunched according to the instructions at Appendix E.5. Meter reading documents must be keypunched according to the instructions at Appendix E.10. Use the Job Control deck at Appendix F.1 to submit punched occupant check-in cards and the Control Deck at Appendix F.3 to submit the meter readings documents to the system via the remote job entry station.

5.7 Processing an Occupant Check-out.

5.7.1 When a housing unit becomes vacant a FH/MUB Occupant Check-out Sheet must be filled out and meter readings taken for all meters at the unit. The completed check-out sheet and meter reading documents should be submitted for keypunching and entered to the system as soon as possible.

5.7.2 Occupant Check-out sheets must be keypunched according to the instructions at Appendix E.7. Meter reading documents must be keypunched according to the instructions at Appendix E.10. Use the Job Control deck at Appendix F.1 to submit punched occupant check-out cards and the Control Deck at Appendix F.3 to submit meter reading documents to the system via the remote job entry station.

5.8 Processing New Meter Data.

5.8.1 The collection and validation of data pertaining to the physical characteristics of a meter (meter number, manufacturer's serial number, etc.) will occur during the initial load of the FH/MUBS data base or when a new meter device is installed during the test period.

5.8.2 New meter device data are loaded to the FH/MUBS data base with the New Meter Data form at Appendix C.8. Meter data corrections are effected with the Meter Data Change Form at Appendix C.9. Instructions are on the reverse of each sample. Keypunch instructions are at Appendices E.8 and E.9, respectively. Use the Job Control Deck at Appendix F.1 to submit this data to the system via the remote job entry station.

5.9 Processing Utility Bill Receipts.

5.9.1 During the test period if a balance appears on line 12 of the Mock Utility Bill, the stub on the bill marked "Return This Stub" is returned to the housing office as "payment" of a bill. In order to test the billing system, the dollar amount shown on the stub is keypunched and entered into the system to simulate payment.

5.9.2 See Appendix C.11 for a layout of the keypunched utility bill receipt and Appendix E.11 for keypunching instructions.

6. Data Element Correction/Update Procedures

6.1 Data Element Correction.

6.1.1 Locating Data Element Errors. Every document submitted to the system is listed in its original form on a transaction list and then edited for validity and consistency before processing. If errors are detected on input documents the transaction will appear again on an edit list, preceded by an error message (or messages) and pointers over each field in error. The transaction matrix of Appendix G shows the transaction and error list where data from each document will appear.

6.1.2 Resolving Data Element Errors. To resolve data element errors, find the error message in the Error Messages list at paragraph 6.3. Messages are organized alphabetically by message text: common messages (pertaining to all transactions in the system), norm, meter, and occupant messages. Message entries will explain the error and give a reference to codes in two tables. Codes in the first table, the Systems Action Table in paragraph 6.4.1, describe what action the computer took with the transaction and field in error. Codes in the second table, the Error Remedy Table, paragraph 6.4.2, describe how to correct the error (or errors) for resubmission on an appropriate form.

6.1.3 Fatal errors (coded "S1" in the System Action Table and "R1" in the Error Remedy Table) require resubmission of the original transaction after the errors have been corrected. Non-fatal errors (coded 'S2' and 'S3' in the System Action Table and 'R2' through 'R5' in the Error Remedy Table) are corrected in the same manner as a data element change/update. For example, a FH/MUB Data Change/Maintenance form is used to correct a rejected route number, or to change the route on which a meter is read.

6.2 Data Element Update.

6.2.1 Updating Norm Data. Use a Norm Data Changes/Corrections Form to update or change data about a dwelling unit's structural characteristics from pages 2 and 3 of Appendix G. See Appendix C.2 for a sample form and instructions and Appendix E.2 for keypunching instructions.

6.2.2 Updating Meter Data. Use a Family Housing Mock Billing Meter Data Change Form to update or change information about a metering device. See Appendix C.9 for a sample form and instructions and Appendix E.9 for keypunching instructions.

6.2.3 Updating Occupant Data. Use an FH/MUB Occupant Data Change/Maintenance sheet to update or change data about an occupant or his family. Do not use this form as a check-in or check-out form. See Appendix C.6 for a sample form and instructions and Appendix E.6 for keypunching instructions.

6.2.4 Updating Fuel B.t.u. Content. Use the FH/MUBS Fuel Content Changes form to update or change the B.t.u. (British thermal unit) content of fuel oil, natural gas, and propane gas. See Appendix C.3 for a sample form and instructions and Appendix E.3 for keypunching instructions.

6.2.5 Updating Utility Rates. Use the FH/MUBS Rate Form to update or change the station rate per standard unit of measure for each utility. See Appendix C.4 for a sample form and instructions and Appendix E.4 for keypunching instructions.

6.3 Error Messages.

6.3.1 Common Error Messages.

A. Account not found. (or)
Invalid account number.

Meaning. The account number on the transaction is not numeric, missing, or not locatable on the file.

System Action. S1

Error Remedy. R1

B. Invalid activity code.

Meaning. The activity identifier code is missing or not valid.

System Action. S1

Error Remedy. R1

C. Invalid transaction date.

Meaning. The transaction Julian date is not numeric.

System Action. The invalid Julian date is overlaid with the current Julian date.

Error Remedy. None.

6.3.2 Norm Data Error Messages.

A. Allowable codes B C S.

Meaning. The underflooring of the housing unit is not coded as basement, crawl-space, or slab.

System Action. S2

Error Remedy. R2

B. Allowable codes E or C.

Meaning. The horizontal placement of the housing unit must be end or center.

System Action. S2

Error Remedy. R2

C. Allowable codes S D T O.

Meaning. Dwelling type not coded as single family, duplex, townhouse, or other.

System Action. S2

Error Remedy. R2

D. Allowable codes T M L.

Meaning. The vertical placement of the housing unit is not coded as top, middle, or lowest floor.

System Action. S2

Error Remedy. R2

E. Allowable range -41/126.

Meaning. The high and/or low temperature fields are outside the allowable range.

System Action. S2

Error Remedy. R2

F. Allowable range 1-6.

Meaning. The number of pilots specified for the cooking range exceeds the limit.

System Action. S2

Error Remedy. R2

G. Allowable range 1-15.

Meaning. The number of occupants of the housing unit out of the acceptable range.

System Action. S2

Error Remedy. R2

H. Allowable values 0-3.

Meaning. The number of pilots for the hot water heater or furnace exceeds the limit.

System Action. S2

Error Remedy. R2

I. Cooling Hours > 24.

Meaning. The number of hours over 78°F exceeds 24 for a day.

System Action. S2

Error Remed . R2

J. Dwelling requires place code.

Meaning. Horizontal and/or vertical placement code missing.

System Action. S2

Error Remedy. R2

K. Invalid code - C F B M O S allowable.

Meaning. The construction type of the housing unit is not coded as concrete, frame, brick/block, masonry, brick/frame (O), or steel frame.

System Action. S2

Error Remedy. R2

L. Inconsistent data items.

Meaning. The dwelling placement code does not coincide with the structural description. Placement code rejected.

System Action. S2

Error Remedy. R2

M. Invalid field - G E O S H allowed.

Meaning. The hot water heater fuel or the heating fuel is not coded as gas, electricity, oil, steam, or hot water.

System Action. S2

Error Remedy. R2

N. Invalid Fuel - G E O S H C allowed.

Meaning. The cooling fuel is not coded as gas, electricity, oil, steam, hot water, chilled water, or blank.

System Action. S2

Error Remedy. R2

O. Invalid Fuel - G E P allowed.

Meaning. The cooking fuel code is not valid. Must be gas, electricity, or propane.

System Action. S2

Error Remedy. R2

P. Julian day limit 1-366.

Meaning. The Julian day is out of range on the weather transaction.

System Action. S1

Error Remedy. R1

Q. Julian year less than 78.

Meaning. The Julian year is out of range on the weather transaction.

System Action. S1

Error Remedy. R1

R. Must be Y or N.

Meaning. The field requiring a yes or no answer is not coded with a 'Y' or 'N'.

System Action. S2

Error Remedy. R2

S. Non-numeric account #.

Meaning. The account number on the norm transaction is not numeric.

System Action. S1

Error Remedy. R1

T. Non-numeric data.

Meaning. A numeric field has non-numeric data.

System Action. S2

Error Remedy. R2

U. Stories must be coded.

Meaning. The number of stories for a housing unit has not been coded.

System Action. S2

Error Remedy. R2

V. Unidentified field code.

<u>Meaning</u>. An invalid mnemonic code has been entered.

<u>System Action</u>. S2

<u>Error Remedy</u>. R2

W. Bldg-acct inconsistent.

<u>Meaning</u>. The building number coded does not match the building number associated with the account number on the file. Transaction will be entered against the account number.

<u>System Action</u>. S3

<u>Error Remedy</u>. R3

X. Water temp less 32.

<u>Meaning</u>. The source water temperature was coded as less than 32 (freezing).

<u>System Action</u>. S2

<u>Error Remedy</u>. R2

6.3.3 Meter Reading Document Error Messages.

A. Current Reading Invalid.

Meaning. The current reading for this meter is missing or not numeric.

System Action. S1

Error Remedy. R1

B. Current Reading not greater than Present Reading.

Meaning. The current reading on the meter reading document for this meter is not greater than the most recent reading on the account file.

System Action. S1

Error Remedy. R1

C. Current Reading outside of HI-LO Range and not verified.

Meaning. The current reading field content is outside the permitted range, and was not verified.

System Action. S1

Error Remedy. R1

D. Date of Reading Invalid.

Meaning. The date of reading field on this meter reading transaction is not numeric.

System Action. S1

Error Remedy. R1

E. Master Meter Not Found.*

Meaning. The master meter number could not be located on the Master File.

System Action. S1

Error Remedy. R1

* These error messages pertain only to master/slave meter networks.

F. Master Meter Number Invalid.*

Meaning. The master meter number does not conform to the convention for numbering meters.

System Action. S1

Error Remedy. R1

G. Meter Number Invalid.

Meaning. The meter number does not conform to the convention for numbering meters.

System Action. S1

Error Remedy. R1

H. Meter Number Not Found.

Meaning. The meter number could not be located on the Master File.

System Action. S1

Error Remedy. R1

I. Missing Meter Reading Within an Account.

Meaning. All meters for an account were not read. Billing is not possible.

System Action. S1

Error Remedy. R1

J. No Reader Code.

Meaning. The Reader Code is missing.

System Action. S3

Error Remedy. R3

K. Reader Code Invalid.

<u>Meaning</u>. The Reader Code is not numeric.

<u>System Action</u>. S3

<u>Error Remedy</u>. R3

L. Sequence Changed.

<u>Meaning</u>. The sequence a meter is read in has been changed. This message is for information only.

<u>System Action</u>. S3

<u>Error Remedy</u>. None.

M. Sequence Invalid.

<u>Meaning</u>. The new sequence number is not numeric.

<u>System Action</u>. S2

<u>Error Remedy</u>. R2

N. Transaction Date Invalid.

<u>Meaning</u>. The transaction Julian date is invalid.

<u>System Action</u>. The invalid Julian date is overlaid with the current Julian date.

<u>Error Remedy</u>. None.

O. Type of Reading Invalid.

<u>Meaning</u>. The type of reading field is not blank, I, O, or C.

<u>System Action</u>. S1

<u>Error Remedy</u>. R1

P. Unable to compute master/slave ratio - not S, G, or W.*

Meaning. The master and slave meter utility types were found to be different when an attempt was made to calculate billable units. All master/slave meters must be on the same type: S = steam; G = gas; W = hot water.

System Action. S1

Error Remedy. R1

Q. Current Reading beyond High-Low and verified.

Meaning. Warning. The recorded meter reading exceeded the predicted range.

System Action. S3

Error Remedy. R3

R. Zero usage - check for non-recording.

Meaning. Warning. The current reading was identical to prior reading - no usage recorded.

System Action. S3

Error Remedy. R3

S. Missing Slave Reading for Master Meter.*

Meaning. All slave meters for the master meter were not read.

System Action: S1

Error Remedy: R1

T. Transaction Code not 'MR'.

Meaning: The system cannot recognize the transaction.

System Action: S1

Error Remedy: R1

U. Verification Invalid.

Meaning: Verification code not blank or "V".

System Action: S3

Error Remedy: R3

V. Reading Table Overflow.*

Meaning. More than 27 readings were submitted for a master meter.

System Action: S1

Error Remedy: R1

W. Master Meter Reading Outside High-Low Range and not Verified.*

Meaning. The master meter current reading field is outside the permitted range and was not verified.

System Action: S1

Error Remedy: R1

X. Rejected Because of Previous Error.

Meaning. If multiple readings with different read dates are submitted for a meter, earlier readings must be correct for a later reading to be accepted.

System Action: S1

Error Remedy: R1

Y. Duplicate Record.

Meaning: Two or more reading documents for a meter were submitted with the same read dates. First document accepted.

System Action: S1

Error Remedy: R3

Z. Month Out of Range.

Meaning: Month of reading not in range 1-12.

System Action: S1

Error Remedy: R1

AA. Day Out of Range.

Meaning: Day of reading not in range 1-31.

System Action: S1

Error Remedy: R1

BB. Master Meter Number Missing.*

Meaning: The master meter number omitted from a slave meter reading document.

System Action: S1

Error Remedy: R1

CC. Account Rejects.

Meaning: Meter readings rejected due to preceeding error.

System Action: S1

Error Remedy: R1

DD. Slave Error.*

Meaning: Meter reading in error is for a slave meter, and will cause all slaves attached to the same master meter to reject.

System Action: S1

Error Remedy: R1

6.3.4 Meter Reading Document Request Error Messages.

A. Activity Code Error. Value found XXXXXX. Job terminated.

Meaning. The activity code is invalid.

System Action. S1

Error Remedy. R1

B. Read Date Error. Value found XXXXXX.

Meaning. The date on the Meter Reading Document Request Form does not conform to following:

```
YY  MM  DD
|   |   ↓
|   |   Range 01-31
|   ↓
|   Range 01-12
↓
Must be greater than 77
```

System Action. S1

Error Remedy. R1

C. Route Number Error. Value found XX. Route not processed.

Meaning. The route number assigned is not numeric.

System Action. S2

Error Remedy. R2

D. Transaction and/or Type Code Error. Value found XX.

Meaning. Card columns 1-2 not equal to 'CM'.

System Action. S1

Error Remedy. R1

6.3.5 Meter Data Error Messages.

A. Invalid bldg. #.

Meaning. The building number on the new meter data transaction is not the same as the building number on the Master File. The transaction will be entered against the account number.

System Action. S3

Error Remedy. R3

B. Invalid category code.

Meaning. Category of quarters not A, B, C, D, or E.

System Action. S2

Error Remedy. R2

C. Invalid change for master meter.

Meaning. An attempt was made to change or update data not applicable to a master meter (e.g., rate, second and third line of the address).

System Action. S2

Error Remedy. R2

D. Invalid dispositon code.

Meaning. The removed meter disposition code was not 'DS', 'RS', or 'IN'.

System Action. S2

Error Remedy. R2

E. Invalid Meter #.

Meaning. The meter number does not conform to the convention for numbering meters.

System Action. S1

Error Remedy. R1

F. Invalid mnemonic code.

Meaning. The mnemonic field identifier is not valid.

System Action. S2

Error Remedy. R2

G. Invalid placement code.

Meaning. The meter placement code indicating the position of the meter at the service location is not valid.

System Action. S2

Error Remedy. R2

H. Meter already exists.

Meaning. The meter number on the New Meter Data form is already in use on the master file.

System Action. S1

Error Remedy. R1

I. Meter buckets full.

Meaning. Too many meters at an account. A maximum of seven meters is allowed at an account.

System Action. S1

Error Remedy. R1

6.3.6 Occupant Data Error Messages.

A. Account already occupied.

Meaning. An occupant check-in was attempted against an account which is already occupied.

System Action. S1

Error Remedy. R4

B. Account already vacant.

Meaning. An occupant check-out was attempted against an account which is already vacated.

System Action. S1

Error Remedy. R5

C. Invalid Dependents.

Meaning. The number of dependents has to be 14 or less

System Action. S2

Error Remedy. R2

D. F Invalid Mnemonic.

Meaning. The mnemonic code for this key field is not valid.

System Action. S1

Error Remedy. R1

E. T Invalid Mnemonic.

Meaning. The mnemonic code for this field is not valid.

System Action. S2

Error Remedy. R2

F. Occupant not found.

Meaning. The occupant number is invalid or missing.

System Action. S1

Error Remedy. R1

6.4 System Action and Error Remedy Tables.

6.4.1 System Action Table.

Code	System Action
S1	Fatal Error: The entire transaction is rejected.
S2	Non-Fatal Error: Only the data in error is rejected; the remainder of valid data on the transaction is accepted.
S3	A warning message is issued, the transaction is processed and data is accepted as shown.

6.4.2 Error Remedy Table.

Code	Remedy
R1	Correct the field(s) in error. Resubmit the entire original transaction after correction(s) made.
R2	Correct the field in error. Submit an appropriate change/maintenance transaction.
R3	Check data to insure it is valid. If the data is not valid, correct or update the indicated fields using the appropriate change/maintenance form.
R4	Check for the proper account number. If the housing unit is in fact occupied, research the transaction and submit a new transaction with a corrected account number. If the housing unit is in fact vacant, submit a check-out transaction and resubmit the original check-in transaction.
R5	Check for the proper account number. If the housing unit is in fact vacant, research the transaction. If the document in error is a duplicate transaction, no further action is required. Otherwise, submit a new transaction with the correct account number.

APPENDIX A

Data Element Dictionary

Data Element Number: DE 1

Name: Account Number

Mnemonic Code: None

Size: 6N

Definition: A six digit identifier assigned to a metered service location with ranges prescribed for each activity, as follows:

Great Lakes: 001000 - 003999
Port Hueneme: 004000 - 004999
Point Mugu: 005000 - 006999
Quantico: 007000 - 008999
Beaufort: 009000 - 010999
Little Rock: 110001 - 112999
Cannon AFB: 013000 - 014999
Ft. Eustis: 015000 - 016999
Ft. Gordon: 017000 - 018999
Yuma Proving Ground: 001900 - 020999

Edits: Must be numeric.

Data Element Number: DE 2

Name: Activity Code

Mnemonic Code: None

Size: 6AN

Definition: A unique six-digit identifier for each activity participating in the FH/MUBS test.

Edits: Must be one of the following:

N65113 - PWC Great Lakes
N62583 - CBC Port Hueneme
N63126 - PMTC Point Mugu
NXX498 - Camarillo Housing
M00264 - MCDEC Quantico
M60169 - MCAS Beaufort
AFNKAK - Little Rock AFB
CVNKAK - AF Control Group
AFCZQZ - Cannon AFB
CVCZQZ - AF Control Group
A51215 - Fort Eustis
A13055 - Fort Gordon
A04985 - Yuma Proving Grounds

Data Element Number: DE 3

Name: Adjusted Reading

Mnemonic Code: AR

Size: 7N

Definition: This reading changes the most current meter reading on the master file. For example, this field is used to record the reading of a replacement meter on the date of installation. It may not be used to correct a rejected meter reading.

Edits: Must be numeric.

Data Element Number: DE 4

Name: Air Change Rate/ACR

Mnemonic Code: None.

Size: 3N

Definition: The rate the entire volume of air in the dwelling unit turns over each hour.

Edits: Must be in the range of 0.00 to 2.00.

Data Element Number: DE 5

Name: Attic (Flag)

Mnemonic Code: AT

Size: 1A

Definition: This flag denotes whether the housing unit has an attic.

Edits: Must be one of the following:

Y = housing unit has an attic.
N = housing unit does not have an attic.

Data Element Number: DE 6

Name: Basement/Crawl/Slab

Mnemonic Code: BS

Size: 1A

Definition: Describes the under flooring of the housing unit.

Edits: Must be one of the following:

B = basement (unheated, with access)
C = crawl space (unheated, without access)
S = concrete slab or heated basement with access
" "= if vertical placement (DE) = top or middle

Data Element Number: DE 7

Name: Bedrooms

Mnemonic Code: BD

Size: 2N

Definition: The number of bedrooms in the housing unit.

Edits: Must be numeric.

Data Element Number: DE 8

Name: Billing Address, Line 1

Mnemonic Code: BA

Size: 20AN

Definition: The first line of the mailing address if it is different than the metered service address. This data element is used on a check-in and data change/ maintenance form.

Edits: Maximum of 20 characters.

Data Element Number: DE 9

Name: Billing Address, Line 2

Mnemonic Code: BB

Size: 20AN

Definition: The second line of the mailing address if it is different than the metered service address. This data element is used on a check-in and data change/maintenance form.

Edits: Maximum of 20 characters.

Data Element Number: DE 10

Name: Billing Address, Line 3

Mnemonic Code: BC

Size: 20AN

Definition: The third line of the mailing address if it is different than the metered service address. This data element is used on a check-in and data change/ maintenance form.

Edits: Maximum of 20 characters.

Data Element Number: DE 11

Name: Building Category

Mnemonic Code: CA

Size: 1A

Definition: The category of quarters applicable to the housing unit to which the meter is attached.

Edits: Must be one of the following:

A = Wherry
B = Fund 1970 and after
C = Fund 1950-1969
    Capehart
    Fund 1950-1969
    USA Home
    Surplus Commodity
D = Other Public Quarters (OPQ)
    Prior 1950
    Relocatable
    Foreign Source
E = Substandard
    Other IPQ
    Title III Trailers
    Trailers

Data Element Number: DE 12

Name: Building Mass Factor/B2

Mnemonic Code: None.

Size: 4N

Definition: A derivative of the U-factor, the volume of the building, and the floor and ceiling construction characteristics. Expressed as 1 over degrees farenheit per day.

Edits: Maximum of 4 digits.

<u>Data Element Number</u>: DE 13

<u>Name</u>: Building Number

<u>Mnemonic Code</u>: BN

<u>Size</u>: 6AN

<u>Definition</u>: The six-digit dwelling unit identifier assigned to the housing unit.

<u>Edits</u>: Maximum of six characters.

Data Element Number: DE 14

Name: Calendar Date

Mnemonic Code: None

Size: 6N

Definition: The calendar date in the format Year Year Month Month Day Day; e.g. 2 January 1978 would be coded as 780102.

Edits: Must be numeric; and in the following ranges:

YY MM DD

Range 01-31

Range 01-12

Must be greater than 77.

Data Element Number: DE 15

Name: Construction Type

Mnemonic Code: CT

Size: 1A

Definition: The materials of which each housing unit is built.

Edits: Must be one of the following:

C = precast concrete
F = frame
B = brick/block
M = masonry
O = brick/frame
S = steel frame

Data Element Number: DE 16

Name: Cooling System Coefficient (COP)

Mnemonic Code: None.

Size: 3N

Definition: The dimensional efficiency of the cooling system in a housing unit.

Edits: Must be in the range of .00 to 4.00.

Data Element Number: DE 17

Name: COP Adjustment Factor (C1)

Mnemonic Code: None.

Size: 2N

Definition: The dimentsional bias factor used to adjust air-conditioner performance.

Edits: Must be in the range of .00 to .99.

Data Element Number: DE 18

Name: Dwelling Type

Mnemonic Code: DT

Size: 1A

Definition: Describes the style of the housing unit.

Edits: Must be one of the following codes:

S = single family
D = duplex
T = townhouse
O = other

Data Element Number: DE 19

Name: Floor Area

Mnemonic Code: FA

Size: 4N

Definition: The square footage of housing unit living area as determined by the field survey and construction drawings.

Edits: Must be numeric; maximum field length = 4 digits.

Data Element Number: DE 20

Name: Forward Address, Line 1

Mnemonic Code: BA

Size: 20AN

Definition: The first line of the forwarding address. This data element is used on a check-out and data change/ maintenance form.

Edits: Maximum of 20 characters.

Data Element Number: DE 21

Name: Forward Address, Line 2

Mnemonic Code: BB

Size: 20AN

Definition: The second line of the forwarding address. This data element is used on a check-out and data change/maintenance form.

Edits: Maximum of 20 characters.

Data Element Number: DE 22

Name: Forward Address, Line 3

Mnemonic Code: BC

Size: 20AN

Definition: The third line of the forwarding address. This data element is used on a check-out and data change/maintenance form.

Edits: Maximum of 20 characters.

Data Element Number: DE 23

Name: Fuel-Cooking

Mnemonic Code: FC

Size: 1A

Definition: The fuel used for cooking in the housing unit.

Edits: Must be one of the following codes:

G = gas
E = electric
P = propane

Data Element Number: DE 24

Name: Fuel-Cooling

Mnemonic Code: FL

Size: 1A

Definition: The fuel used for cooling the housing unit.

Edits: Must be one of the following codes:

G = gas
E = electric
O = oil
S = steam
H = hot water
C = chilled water
' '= none

Data Element Number: DE 25

Name: Fuel-Heating

Mnemonic Code: FH

Size: 1A

Definition: The fuel used for heating the housing unit.

Edits: Must be one of the following codes:

G = gas
E = electric
O = oil
S = steam
H = hot water
P = propane

Data Element Number: DE 26

Name: Fuel-Hot Water Heater

Mnemonic Code: FW

Size: 1A

Definition: The fuel used for the hot water heater in the housing unit.

Edits: Must be one of the following codes:

G = gas
E = electricity
O = oil
S = steam
H = hot water

Data Element Number: DE 27

Name: Heating System Efficiency/EFFFUR

Mnemonic Code: None.

Size: 2N

Definition: The dimensional effectiveness of the furnace in the housing unit.

Edits: Must be in the range .00 to .99.

Data Element Number: DE 28

Name: Horizontal Placement

Mnemonic Code: HP

Size: 1A

Definition: The horizontal relation of a housing unit in a building with more than two dwelling units.

Edits: Must be one of the following:

Blank if dwelling type = single family or duplex.
"E" for end or "C" for center if dwelling type = townhouse or other.

Data Element Number: DE 29

Name: Hot Water Heater Efficiency (EFFDWH)

Mnemonic Code: None.

Size: 2N

Definition: The dimensional effectiveness of the hot water heater in a housing unit.

Edits: Must be in the range of .00 to .99.

Data Element Number: DE 30

Name: Infiltration Load Factor/C2

Mnemonic Code: None.

Size: 3N

Definition: The dimensional rate of warm air penetration into, and cold air seepage out of, the dwelling unit envelope.

Edits: Maximum of 3 digits.

Data Element Number: DE 31

Name: Internal Gain Constant/B1

Mnemonic Code: None.

Size: 5N

Definition: Internal heat gain not attributable to pilot lights (i.e. appliances, bodies, lights). Expressed in degrees farenheit per day.

Edits: Must be in the range of ±.9999 to ± 9999.

Data Element Number: DE 32

Name: Internal Load Level/IG

Mnemonic Code: None.

Size: 3N

Definition: The internal heat gain not attributable to pilot lights (i.e. appliances, bodies, lights). Expressed in B.t.u.'s per hour per square foot.

Edits: Maximum of 3 digits.

Data Element Number: DE 33

Name: Julian Date

Mnemonic Code: None

Size: 5N

Definition: A Julian date expresses a calendar date in numbers only. The first two digits are the current year. The last three digits express the day of the month as one of the 365 or 366 days of the year. For example, Monday, February 6, 1978 is the 37th day of 1978; its Julian date is 78037.

Edits: The first two digits must be greater than 77; the last three digits must be in the range of 1-366.

Data Element Number: DE 34

Name: Meter Number

Mnemonic Code: MN

Size: 7AN

Definition: The data chain to be used at all activities consisting of an alpha code, followed by four numeric digits, one alpha, and another numeric. The first alpha code is an activity identifier and distinguishes an activity from others; the next four digits are sequential numbers. The sixth digit identifies the utility type, and the seventh digit identifies the source of the consumption.

Edits: The first character must be alphabetic.
The next four digits must be numeric.
The utility type must equal one of the following:

E = electricity
G = natural gas
P = propane
S = steam
F = fuel oil
W = hot water heat

The source of consumption must equal one of the following:

0 - meter servicing a dwelling unit
1 - meter servicing a garage
2 - meter servicing a laundry room
3 - meter servicing storage sheds/bins
4 - meter servicing tennis courts/recreational areas
5 - meter servicing a greenhouse
6 - meter servicing detached stewards', orderlies' or maids' quarters
7 - designates a second meter for a particular utility at the same location, e.g.

A 0001G0 = gas meter at a unit
A 0001G7 = second gas meter at a unit

8 - meter servicing a common usage area
9 - meter servicing a common energy source such as a boiler which requires a ratio to determine the current reading for two or more units.

Data Element Number: DE 35

Name: Meter Serial Number

Mnemonic Code: MS

Size: 8AN

Definition: The manufacturer's serial number on the metering device. If the serial number exceeds 8 characters, the 8 low order characters are used.

Edits: Maximum of 8 characters.

Data Element Number: DE 36

Name: Meter Service Address

Mnemonic Code: AD

Size: 20AN

Definition: The number and street of the service meter location.

Edits: May not exceed 20 characters.

Data Element Number: DE 37

Name: Move-in Date

Mnemonic Code: MI

Size: 6N

Definition: The date that a dwelling unit becomes occupied, in the format Year Year Month Month Day Day.

Edits: Must be numeric and in the following ranges:

YY MM DD

DD: Range 01-31

MM: Range 01-12

YY: Must be greater than 77.

Data Element Number: DE 38

Name: Move-out Date

Mnemonic Code: MO

Size: 6N

Definition: The date that a dwelling unit is vacated, in the format Year Year Month Month Day Day.

Edits: Must be numeric and in the following ranges:

```
YY MM DD
|  |  ↓
|  |  Range 01-31
|  ↓
|  Range 01-12
↓
Must be greater than 77.
```

__Data Element Number__: DE 39

__Name__: Number of Dependents

__Mnemonic Code__: DE

__Size__: 2N

__Definition__: The number of qualified dependents who reside at the housing unit __(excludes the individual to whom the unit is assigned)__.

__Edits__: Must be numeric; range 01-14.

Data Element Number: DE 40

Name: Number of Stories

Mnemonic Code: ST

Size: 1N

Definiton: The number of heated stories in the housing unit (including the basement, if heated).

Edits: Must be numeric; maximum field length = 1 digit.

Data Element Number: DE 41

Name: Occupant Name

Mnemonic Code: NA

Size: 16AN

Definition: One or two initials, followed by a space, followed by the last name of the responsible occupant; e.g., MH Jones; G Brown.

Edits: Maximum of 16 characters.

Data Element Number: DE 42

Name: Occupant Number

Mnemonic Code: None

Size: 2N

Definition: A two-digit computer generated number identifying the occupant. This data element is used on a check-out and data change/maintenance form.

Edits: The occupant number on a change/maintenance form must match a current or previous occupant number, the occupant number on a check-out form must match the current occupant number on the file.

Data Element Number: DE 43

Name: Outside Chilled Water Consumption

Mnemonic Code: CW

Size: 6N

Definition: The estimated daily outside chilled water consumption (in B.t.u.s) billed to the housing unit.

Edits: Must be numeric; maximum field length = 6 digits.

Data Element Number: DE 44

Name: Outside Electric Consumption

Mnemonic Code: OE

Size: 3N

Definition: The estimated daily outside electrical consumption billed to the housing unit.

Edits: Must be numeric; maximum field length = 3 digits.

Data Element Number: DE 45

Name: Outside Gas Consumption

Mnemonic Code: OG

Size: 6N

Definition: The estimated daily outside gas consumption (in BTUs) billed to the housing unit.

Edits: Must be numeric; maximum field length = 6 digits.

Data Element Number: DE 46

Name: Outside Hot Water Consumption

Mnemonic Code: OH

Size: 6N

Definition: The estimated daily hot water consumption (in BTUs) billed to the housing unit.

Edits: Must be numeric; maximum field length = 6 digits.

Data Element Number: DE 47

Name: Outside Oil Consumption

Mnemonic Code: OO

Size: 6N

Definition: The estimated daily outside oil consumption (in BTUs) billed to the housing unit.

Edits: Must be numeric; maximum field length = 6 digits.

Data Element Number: DE 48

Name: Outside Steam Consumption

Mnemonic Code: OS

Size: 6N

Definition: The estimated daily outside steam consumption (in BTUs) billed to the housing unit.

Edits: Must be numeric; maximum field length = 6 digits.

Data Element Number: DE 49

Name: Pay Grade

Mnemonic Code: GR

Size: 3AN

Definition: Military, civil service, wage board, or other pay grade of the responsible occupant.

Edits: The first character may be:

1. E = Enlisted. Valid codes are 01-09.
2. W = Warrant Officer. Valid codes are 01-04.
3. O = Officer. Valid codes are 01-10.
4. G = General Schedule. Valid codes are 01-18.
5. B = Wage Board (WG/WL/WS). Valid codes are 01-19.

If the responsible occupant is a foreign national, enter "FNA".

If none of the above applies to the responsible occupant, enter "OTH".

Data Element Number: DE 50

Name: Pilots-Air Conditioner

Mnemonic Code: PA

Size: 1N

Definition: The number of pilot lights, used to ignite a gas air conditioner. Applies only if housing unit has its own compressor.

Edits: Must be numeric, range 0-2.

Data Element Number: DE 51

Name: Pilots-Dryer

Mnemonic Code: PD

Size: 1N

Definition: The number of pilot lights, within the unit envelope, used to ignite a clothes dryer.

Edits: Must be numeric, range 0-2.

Data Element Number: DE 52

Name: Pilots-Furnace

Mnemonic Code: PF

Size: 1N

Definition: The number of pilot lights, within a unit envelope, used to ignite a furnace.

Edits: Must be numeric; range 0-3.

Data Element Number: DE 53

Name: Pilots-Range

Mnemonic Code: PR

Size: 1N

Definition: The number of pilot lights, within the unit envelope, used to ignite a range.

Edits: Must be numeric, range 0-6.

If the range is electric, this field must be zero.

Data Element Number: DE 54

Name: Pilots-Water Heater

Mnemonic Code: PW

Size: 1N

Definition: The number of pilot lights, within the unit envelope, used to ignite a domestic hot water heater.

Edits: Must be numeric; range 0-3.

Data Element Number: DE 55

Name: Placement

Mnemonic Code: NP

Size: 2N

Definition: A two-digit code indicating the placement of the meter at the service location.

Edits: Must be one of the following:

Main House - Inside Basement
- 01 - Rear Wall
- 02 - Front Wall
- 03 - Furnace Room
- 04 - Stairway

First Floor
- 10 - Hall
- 11 - Bedroom
- 12 - Kitchen
- 13 - Bathroom
- 14 - Living Room
- 15 - Dining Room
- 16 - Closet
- 17 - Stairway

Second Floor
- 20 - Hall
- 21 - Bedroom
- 22 - Kitchen
- 23 - Bathroom
- 24 - Living Room
- 25 - Dining Room
- 26 - Closet
- 27 - Stairway

Main House - Outside
- 40 - Back Porch
- 41 - Front Porch
- 42 - Left Side
- 43 - Right Side
- 44 - Under House
- 45 - Under Steps
- 46 - On Pole

Other Buildings

Shed
- 50 - Inside Wall
- 51 - Outside Wall
- 52 - On Pole

Garage
- 60 - Inside Wall
- 61 - Outside Wall
- 62 - On Pole

Laundry Room
- 70 - Inside Wall
- 71 - Outside Wall
- 72 - On Pole

Greenhouse
- 80 - Inside Wall
- 81 - Outside Wall
- 82 - On Pole

Recreational Areas
- 90 - Inside Wall
- 91 - Outside Wall
- 92 - On Pole.

Data Element Number: DE 56

Name: Rank/Rate

Mnemonic Code: RK

Size: 4AN

Definition: The rank or rate abbreviation of the responsible occupant (e.g., Lieutenant Colonel (LTC), Lieutenant Junior Grade (LTJG), or Petty Officer Third Class (PO3)).

Edits: Maximum of 4 characters.

Data Element Number: DE 57

Name: Reading Constant

Mnemonic Code: RC

Size: 6N

Definition: The number a meter reading must be multiplied by to derive standard units of measure. The format for the reading constant is two-digits plus four decimal places.
This field is not required for slave meters or if the meter reads in the following standard units:

Electricity: Kilowatt hours
Natural Gas: Hundreds of cubic feet
Oil: Gallons
Steam: Therms
Hotwater Heat: Therms
Propane: Pounds.

Edits: Must be numeric.

Data Element Number: DE 58

Name: Reading Sequence

Mnemonic Code: SQ

Size: 3N

Definition: The sequence in which a meter is to be read within a route.

Edits: Must be numeric.

Data Element Number: DE 59

Name: Receipt Date

Mnemonic Code: RD

Size: 6N

Definition: The date the meter was received at an installation, in the format Year Year Month Month Day Day.

Edits: Must be numeric, and in the following ranges:

```
YY MM DD
|  |  ↓
|  |  Range 01-31
|  ↓
|  Range 01-12
↓
Must be greater than 77.
```

Data Element Number: DE 60

Name: Removed Meter Dispositon

Mnemonic Code: OD

Size: 2A

Definition: Disposition of a meter which has been removed from a dwelling unit.

Edits: Valid codes are:

DS - Disposed
RS - Repair Shop/Recalibrated
IN - Instock/Warehouse.

Data Element Number: DE 61

Name: Route Number

Mnemonic Code: RN

Size: 2N

Definition: The two-digit designator for the route a meter is read on. A master meter and related slave meters must be included in the same route to insure they are all read on the same date.

Edits: Must be numeric.

Data Element Number: DE 62

Name: Set Point Temperature Factor/B3

Mnemonic Code: None.

Size: 2N

Definition: A computer modeled optimum setting for temperature control in the housing unit.

Edits: Must be in the range .00 to .99.

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FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
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Data Element Number: DE 63

Name: Solar Load Factor/C3

Mnemonic Code: None.

Size: 4N

Definition: The dimensional figure derived from historic cloud cover, roof surface and insulation and shading of the housing unit.

Edits: Maximum of 4 digits.

Data Element Number: DE 64

Name: Storm Proofing (Flag)

Mnemonic Code: SP

Size: 1A

Definition: The flag denoting if a housing unit has storm doors and windows.

Edits: Must be one of the following:

Y = The housing unit has storm doors and windows.
N = All other conditions.

Data Element Number: DE 65

Name: Total Dollars Billed

Mnemonic Code: DB

Size: 7N

Definition: The total dollars billed to an occupant in a billing period. A maximum of five digits plus two decimal places.

Edits: Must be numeric.

Data Element Number: DE 66

Name: Total Dollars Received

Mnemonic Code: DR

Size: 7N

Definition: The total dollar amount received from an occupant in a billing period.

Edits: Must be numeric.

Data Element Number: DE 67

Name: U Factor and Infiltration Constant/A

Mnemonic Code: None.

Size: 6N

Definition: A value that corresponds to the conduction of heat through the surfaces of the building exposed to the outside air and the heat required to raise the temperature of the air which infiltrates to the building space.

Edits: Maximum of 6 digits.

Data Element Number: DE 68

Name: Vertical Placement

Mnemonic Code: VP

Size: 1A

Definition: The vertical relation of a housing unit in a building with more than two dwelling units.

Edits: Must be one of the following:

Blank if dwelling type = single family or duplex. "T" for top floor, "M" for middle floor; or "L" for lowest floor if dwelling type = townhouse or other.

Data Element Number: DE 69

Name: Volume

Mnemonic Code: VO

Size: 5N

Definition: The volume in cubic feet of the heated and cooled space in the housing unit.

Edits: Must be numeric; maximum field length = 5 digits.

Data Element Number: DE 70

Name: Weather Stripping (Flag)

Mnemonic Code: WS

Size: 1A

Definition: The flag denoting if a housing unit has been weather stripped and caulked.

Edits: Must be one of the following:

Y = The housing unit is weather stripped and caulked.
N = All other conditions.

Data Element Number: DE 71

Name: Window Area

Mnemonic Code: WA

Size: 3N

Definition: The area, in square feet, of the windows in the housing unit.

Edits: Must be numeric; maximum field length = 3 digits.

Data Element Number: DE 72

Name: Year Built

Mnemonic Code: YR

Size: 2N

Definition: The decade and year of construction of the housing unit.

For example, 1965 would be coded as "65". If prior to 1900, "00" is coded.

Edits: Must be numeric; maximum field length = 2 digits.

B. Mnemonic Code Dictionary

Mnemonic	Data Element
AD	Meter Service Address
AR	Adjusted Reading
AT	Attic (Flag)
BA	Billing/Forward Address, Line 1
BB	Billing/Forward Address, Line 2
BC	Billing/Forward Address, Line 3
BD	Bedrooms
BN	Building Number
BS	Basement/Crawl/Slab
CA	Building Category
CT	Construction Type
CW	Outside Chilled Water Consumption
DB	Total Dollars Billed
DE	Number of Dependents
DR	Total Dollars Received
DT	Dwelling Type
FA	Floor Area
FC	Fuel-Cooking
FL	Fuel-Cooling
FH	Fuel-Heating
FW	Fuel-Hot Water Heater
GR	Pay Grade
HP	Horizontal Placement
MI	Move-in Date
MN	Meter Number
MO	Move-out Date
MS	Meter Serial Number
NA	Occupant Name
NP	Placement
OD	Removed Meter Dispositon
OE	Outside Electric Consumption
OG	Outside Gas Consumption
OH	Outside Hot Water Consumption
OO	Outside Oil Consumption
OS	Outside Steam Consumption
PA	Pilots-Air Conditioners
PD	Pilots-Dryer
PF	Pilots-Furnace
PR	Pilots-Range
PW	Pilots-Water Heater
RC	Reading Constant
RD	Receipt Date
RK	Rate/Rank
RN	Route Number
SP	Storm Proofing (Flag)
SQ	Reading Sequence
ST	Number of Stories
VO	Volume
VP	Vertical Placement
WA	Window Area
WS	Weather Stripping (Flag)
YR	Year Built

Activity Weather Log

A. $\boxed{1}$ Weather Log
1

B. $\boxed{\ }$ Type of Weather Transaction
2
'2' = New Weather
'3' = Correction

C. [| | | | |] Activity Code
3 8

D. [| | | |] Julian Date (YYDDD)
21 25

E. [| |] Enter the high temperature for day.
26 28

F. [| |] Enter the low temperature for day.
29 31

G. [|] Enter the number of hours during which the temperature went above 78° for day in 'D'. If none, enter zeroes.
32 33

H. [|] Enter the average temperature of water supplying domestic hot water heaters.
34 36

A. $\boxed{1}$ Weather Log
1

B. $\boxed{\ }$ Type of Weather Transaction
2
'2' = New Weather
'3' = Correction

C. [| | | | |] Activity Code
3 8

D. [| | | |] Julian Date (YYDDD)
21 25

E. [| |] Enter the high temperature for day.
26 28

F. [| |] Enter the low temperature for day.
29 31

G. [|] Enter the number of hours during which the temperature went above 78° for day in 'D'. If none, enter zeroes.
32 33

.. [|] Enter the average temperature of water supplying domestic hot water heaters.
34 36

Instructions for Completing the Activity Weather Log

1. To Submit New Weather Data.

   a. The "1" in position 1 identifies this transaction as weather and water temperature data to the computer.

   b. Enter '2' in position 2.

   c. Enter the Activity Code starting in position 3.

   d. Enter the Julian Date of the day the temperatures were recorded starting in position 21.

   e. Enter the highest temperature (°F) recorded at the activity during the 24-hour day logged in 'd' above starting in position 26.

   Use all three positions. For example, 75°F would be entered as Ø75.

   If the reading is below zero, place a minus sign to the left of the three blocks and enter the number as above.

   f. Enter the lowest temperature (°F) recorded at the activity during the 24-hour day logged in 'd' above starting in position 29.

   Use all three positions. For example, 29°F would be entered as Ø29.

   If the reading is below zero, place a minus sign to the left of the three blocks and enter the number as above.

   g. Enter the number of hours during which the temperature (°F) went above 78° for the 24-hour day logged in 'd' above.

   This is the number of hours, not the number of times the thermometer showed a plus 78° reading. If during one hour the temperature read 79, 75 and 80, this is considered one occurrence, one hour during which the temperature went above 78°.

   If the temperature did not go above 78°F enter three zeros.

   h. Enter the average temperature (°F) of the water supplied to housing units beginning in position 34.

2. To Submit Corrected Data.

   a. Enter "3" in position 2.

   b. Enter the Activity Code starting in position 3.

   c. Enter the Julian Date of the original transaction starting in position 21.

   d. Enter the corrected data following the instructions outlined in paragraph one (1) above.

NORM DATA CHANGES/CORRECTIONS FORM

		Activity Code
3	3	
1	2	3

Account #	Bldg. #	Field	Change to	Field	Change to	Field	Change to	Field	Change to
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61
9	15	21	23	43	45	51	53	59	61

Instructions for Completing the Norm Data Changes/Corrections Form

1. Begin at the left-most box for all fields.

*** Changes are made to norm data by keying on activity code, account number and building number. These three fields must be present in order to access the appropriate norm data record. ***

2. Enter your activity code at the top of the form, starting in position 3.

3. Enter the account number of the unit, starting in position 9. This account number will correspond to any changes across a line.

4. Enter the building number of the unit, starting in position 15.

5. Find the appropriate mnemonic code for the data element to be changed.

6. Enter the appropriate mnemonic code starting in position 21.

7. Enter the corrected data starting in position 23.

8. Continue across the line to enter up to 4 corrections per account number. If there are more than 4 corrections to be made to an account number, start a new line, and begin with instruction number 3 above.

9. To enter corrections for a different account number, go to a new line and proceed as described in numbers 3 through 8 above.

Mnemonic Codes for Norm Data Changes/Corrections

Data Element	Mnemonic Code	Data Element	Mnemonic Code
Address	AD	Outside Hot Water Consumption	OH
Attic	AT	Outside Oil Consumption	OI
Basement/Crawl/Slab	BS	Outside Steam Consumption	OS
Bedrooms	BD	Pilots-Air Conditioner	PA
Building Number	BN	Pilots-Dryer	PD
Construction Type	CT	Pilots-Furnace	PF
Dwelling Type	DT	Pilots-Range	PR
Floor Area	FA	Pilots-Water Heater	PW
Fuel-Cooking	FC	Storm Proofing (Flag)	SP ★
Fuel-Cooling	FL★	Vertical Placement	VP
Fuel-Heating	FH★	Volume	VO ★
Fuel-Hot Water Heater	FW	Weather Stripping (Flag)	WS ★
Horizontal Placement	HP	Window Area	WA ★
Number of Stories	ST	Year Built	YR
Outside Chilled Water Consumption	CW		
Outside Electric Consumption	OE		
Outside Gas Consumption	OG		

★ SEE 5-3 BEFORE USING THESE DATA ELEMENTS.

FAMILY HOUSING MOCK UTILITY BILLING SYSTEM

FUEL CONTENT CHANGES

1 [6] transaction code

2 [3] type code

3 [| | | | |] activity code

21 [| | | |] B.t.u.'s per cubic foot of gas

26 [| | | | | |] B.t.u.'s per gallon of oil

38 [| | | |] B.t.u.'s per pound of propane

Instructions for Completing the FH/MUBS Fuel Content Changes Form

1. Begin at the left-most box for all fields.
2. Enter the activity code starting in position 3.
3. Enter B.t.u.'s per cubic foot of gas starting in position 21.
4. Enter B.t.u.'s per gallon of oil starting in position 26.
5. Enter B.t.u.'s per pound of propane starting in position 38.

FAMILY HOUSING MOCK UTILITY BILLING SYSTEM

RATE FORM

Column	Entry	Field
1	[R][U]	Transaction Code
3	[ ][ ][ ][ ][ ][ ]	Activity Code
15	[ ]	Energy Code (See Table)
16	[1]	Rate #
17	[ ][ ][ ][ ].[ ][ ][ ]	Unit Rate
40	[ ][ ][ ][ ][ ][ ]	Effective Date

TABLE

Energy Types	Std. Unit Measure	Energy Code
ELC	KWH	E
NG	CCF	G
OIL	GAL	F
STM	THM	S
HWH	THM	W
LPG	LBS	P

Instructions for Completing the Family Housing Mock Utility Billing System Rate Form

1. Use this form to allocate rates to each utility supplying an activity.

2. Fill out one form for each of the utilities supplying an activity.

3. Begin at the left-most box for all fields with the exception of the unit rate field.

4. Enter the activity code at the top of the form starting in position 3.

5. Enter the energy code in position 15. See the table at the foot of the Rate Form for cross-referencing the energy types with the energy codes.

6. Enter the unit rate in the unit rate block, aligning the rate to the decimal point.

FAMILY HOUSING MOCK UTILITY BILLING
OCCUPANT CHECK-IN SHEET

ACTIVITY CODE [ ][ ][ ][ ][ ][ ] 3

D 1 | 2 2 | ACCOUNT NUM. [ ][ ][ ][ ][ ][ ] 9 | NA 17 | OCCUPANT NAME 19 | MI 39 | MOVE-IN DATE 55

DE 61 | DEPENDENTS 68

D 1 | 3 2 | ACCOUNT NUM. 9 | BA 17 | MAILING ADDRESS IF DIFFERENT FROM RESIDENCE 19 | BB 39 | MORE ADDRESS IF DIFFERENT FROM RESIDENCE 41

D 1 | 3 2 | ACCOUNT NUM. 9 | BC 17 | MORE ADDRESS IF DIFFERENT FROM RESIDENCE 19 | RK 39 | RANK/RATE 41

GR 61 | PAY GRADE 63

Instructions for Completing the FH/MUB Occupant Check-in Sheet

A. General. Each FH/MUB Occupant Check-in Sheet is comprised of three transactions. The first transaction on the sheet must always be completely coded (i.e., an entry for Account Num., NA, MI, and DE). The second transaction is optional. It is coded only if the occupant's mailing address is different from the metered service address. The third transaction must always have an entry for Account Num., RK and GR. The BC entry is coded only if the second transaction has been coded and a third line of address is required.

B. Detailed Instructions.

Enter the activity code at the top of the form, starting in position 3.

First Transaction.

1. Begin at the left-most box for all fields.
2. Enter the account number starting in position 9.
3. Enter up to two initials, followed by a space, followed by the last name, starting in position 19.
4. Enter the date the housing unit became occupied (in the form YYMMDD), starting in position 55.
5. Enter the number of dependents starting in position 68.

C. Second Transaction.

This transaction is coded only if the occupant's mailing address is different from the metered service address.

1. Begin at the left-most box for all fields.
2. Enter the account number starting in position 9.
3. Enter the first line of the mailing address starting in position 19.
4. Enter the second (or last, as the case may be) line of the mailing address starting in position 41.

D. Third Transaction.

The BC entry is optional. All other fields must be coded.

1. Begin at the left-most box for all fields.
2. Enter the account number starting in position 9.
3. If a third line is required for the mailing address, enter the third line of the mailing address starting in position 19.
4. Enter the rank/rate of the responsible occupant starting in position 41.
5. Enter the pay grade of the responsible occupant starting in position 63.

FAMILY HOUSING MOCK UTILITY BILLING
OCCUPANT DATA CHANGE/MAINTENANCE

ACTIVITY CODE
3

D 1	3 2	ACCOUNT NUM. 9	OCCUPANT 15	FIELD 17	CHANGE TO 19	FIELD 39	CHANGE TO 41
			FIELD 61	CHANGE TO 63			
D 1	3 2	ACCOUNT NUM. 9	OCCUPANT 15	FIELD 17	CHANGE TO 19	FIELD 39	CHANGE TO 41
			FIELD 61	CHANGE TO 63			
D 1	3 2	ACCOUNT NUM. 9	OCCUPANT 15	FIELD 17	CHANGE TO 19	FIELD 39	CHANGE TO 41
			FIELD 61	CHANGE TO 63			
D 1	3 2	ACCOUNT NUM. 9	OCCUPANT 15	FIELD 17	CHANGE TO 19	FIELD 39	CHANGE TO 41
			FIELD 61	CHANGE TO 63			

Instructions for Completing the FH/MUB Occupant Data Change/Maintenance Sheet

1. Begin at the left-most box for all fields.

2. Enter the activity code at the top of the form, starting in position 3.

3. Enter the account number, and the two digit occupant number, in positions 9 and 15, respectively.

4. Find the appropriate mnemonic code for the data element to be changed from the list below.

5. Enter the appropriate mnemonic code starting in position 17.

6. Enter the corrected data starting in position 19.

7. Up to three data elements per account number may be corrected by one transaction. If more changes/corrections are required for an account number, code a second transaction, beginning with paragraph three above.

Data Element	Mnemonic Code
Billing/Forward Address, Line 1	BA
Billing/Forward Address, Line 2	BB
Billing/Forward Address, Line 3	BC
Total Dollars Billed	DB
Number of Dependents	DE
Total Dollars Received	DR
Pay Grade	GR
Move-in Date	MI
Move-out Date	MO
Occupant Name	NA
Rate/Rank	RK

FAMILY HOUSING MOCK UTILITY BILLING
OCCUPANT CHECK-OUT SHEET

ACTIVITY CODE

3

D 1 ACCOUNT NUM. OCCUPANT # BA FORWARD ADDRESS BB MORE FORWARD ADDRESS

1 2 9 16 17 19 39 41

MO MOVE-OUT DATE

61 64

D 3 ACCOUNT NUM. OCCUPANT # BC MORE FOWARD ADDRESS

1 2 9 15 17 19

Instructions for Completing the FH/MUB Occupant Check-Out Sheet

A. General.

Each FH/MUB Check-out Sheet is comprised of two transactions. The first transaction on the sheet must always be completely coded (i.e., an entry for Account Number, Occupant Number, BA, BB, and MO). The second transaction is coded only if a third line is required for the forwarding address.

B. Detailed Instructions.

Enter the activity code at the top of the form, starting in position 3.

First Transaction.

1. Begin at the left-most box for all fields.
2. Enter the account number starting in position 9.
3. Enter the occupant number starting in position 15.
4. Enter the first line of the forwarding address starting in position 19.
5. Enter the second line of the forwarding address starting in position 41.
6. Enter the move-out date starting in position 64.

Second Transaction.

This transaction is coded only if a third line is required for the forwarding address.

1. Begin at the left-most box for all fields.
2. Enter the account number starting in position 9.
3. Enter the occupant number starting in position 15.
4. Enter the third line of the forwarding address starting in position 19.

FAMILY HOUSING MOCK BILLING
NEW METER DATA FORM

ACTIVITY CODE
5

2	2	ACCOUNT NUM.	MN	METER NUMBER	BN	BUILDING NO.	MS	METER SERIAL NO.	NP	PLACEMENT
1	2	9	15	17	25	27	35	37	45	47
			RC	READING CONSTANT	RD	receipt date				
			55	57	65	67				
2	3	ACCOUNT NUM.	MN	METER NUMBER	RN	ROUTE NUMBER.	SQ	READING SEQUENCE	CA	bldg category
1	2	9	15	17	25	27	35	37	45	47

Instructions for Completing the Family Housing Mock Billing New Meter Data Form

Use this form when a new meter number is created.

1. Begin at the left-most box for all fields.

2. Enter the activity code at the top of the form, starting in position 3.

3. Enter the account number of the unit in both blocks that begin with position 9. This entry is not required if the meter is a master meter.

4. Enter the meter number in both blocks that begin with position 17.

5. Enter the building number in position 27 for all meters servicing a dwelling unit.

6. Enter the meter serial number in position 37. If the serial number has more than eight characters, enter the eight low order characters.

7. Enter the placement code in position 47.

8. Enter the reading constant in position 57. This entry is not required if the meter reads in the standard unit of measure or is a slave meter used solely for ratio purposes.

9. Enter the receipt date in position 67.

10. Enter the route number and reading sequence starting in position 27 and 37, respectively.

11. Enter the building category in position 47.

This completes the form.

FAMILY HOUSING MOCK BILLING
METER DATA CHANGE FORM

ACTIVITY CODE
3

2	3	ACCOUNT NUM.	MN	METER NUMBER	FIELD	CHANGE TO	FIELD	CHANGE TO	FIELD	CHANGE TO
1	2	9	15	17	25	27	35	37	45	47
			FIELD	CHANGE TO	FIELD	CHANGE TO				
			55	57	65	67				
2	3	ACCOUNT NUM.	MN	METER NUMBER	FIELD	CHANGE TO	FIELD	CHANGE TO	FIELD	CHANGE TO
1	2	9	15	17	25	27	35	37	45	47
			FIELD	CHANGE TO	FIELD	CHANGE TO				
			55	57	65	67				
2	3	ACCOUNT NUM.	MN	METER NUMBER	FIELD	CHANGE TO	FIELD	CHANGE TO	FIELD	CHANGE TO
1	2	9	15	17	25	27	35	37	45	47
			FIELD	CHANGE TO	FIELD	CHANGE TO				
			55	57	65	67				
2	3	ACCOUNT NUM.	MN	METER NUMBER	FIELD	CHANGE TO	FIELD	CHANGE TO	FIELD	CHANGE TO
1	2	9	15	17	25	27	35	37	45	47
			FIELD	CHANGE TO	FIELD	CHANGE TO				
			55	57	65	67				

Instructions for Completing the Family Housing Mock Billing Meter Data Change Form

Use this form to change or correct information about an existing meter.

1. Begin at the left-most box for all fields.

2. Enter the activity code at the top of the form, starting in position 3.

3. Enter the account number of the unit starting in position 9.

4. Enter the meter number starting in position 17.

5. Find the appropriate mnemonic code for the data element to be changed.

6. Enter the appropriate mnemonic code in the "field" section.

7. Enter the changed data in the "change to" section.

You will need one "Field" entry and one "change to" entry for each piece of information you wish to update.

This completes the form.

Mnemonic Codes for Meter Data Changes/Corrections

Data Element	Mnemonic Code	Data Element	Mnemonic Code
Adjusted Reading	AR	Reading Constant	RC
Building Category	CA	Receipt Date	RD
Meter Serial Number	MS	Route Number	RN
Placement	NP	Reading Sequence	SO
Removed Meter Disposition	OD		

ORMAT

1 at of a Keypunched Meter Reading Docume.

COLUMN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HEADING	"MR"		Activity Code						Account and Occupant Number								Meter			
COLUMN	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
HEADING	Number			Read Date						Current Reading							Verification	Master		
COLUMN	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
HEADING	Meter Number				Type of Reading	Reader Code		New Sequence Number			Spaces									
COLUMN	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
HEADING	Spaces															Julian Date				

C-30872

Forı. of a Keypunched Utility Bill Receipt CA JRNAT

COLUMN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
HEADING	"RR"		Activity Code						Account and Occupant Number								Spaces			
COLUMN	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
HEADING	Spaces		Billing Date						Amount Received							Spaces				
COLUMN	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
HEADING	Spaces																			
COLUMN	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
HEADING	Spaces															Julian Date				

C-30873

AUDIT TRAIL REQUEST

1	A R	TRANS/TYPE CODE
3		ACTIVITY CODE
9		BEGINNING JULIAN DATE
14		THRU JULIAN DATE
19		BEGINNING ACCOUNT
25		END ACCOUNT

Instructions for Completing the Audit Trail Request

1. Use this form to obtain a list of transactions submitted to the system by your activity.

2. Begin all fields in the left-most box. Code one character per block.

3. Enter your 6 character activity code, starting in position 3.

4. Enter the 5 digit Julian date that marks the first day to be included in the transaction list beginning in position 9. There _must_ be an entry in this field.

   a. If you want _all_ the transactions submitted by your activity listed, code 'ALL' in this field and leave the remaining fields blank.

   b. If you want only _one_ day's transactions listed, code the day here and leave the field beginning in position 14 blank.

5. Enter the 5 digit Julian date that marks the last day to be included in the transaction list.

   a. If you want _all_ transactions submitted by your activity listed, leave this field blank and code 'ALL' in the field beginning in position 9.

   b. If you want only _one_ day's transactions listed leave this field blank and code the day desired in the field beginning in position 9.

6. Code the first account you want to list transactions for in the field beginning in position 19.

   a. If you want transactions for only one account, code the account here and leave the field beginning in position 25 blank.

   b. If you want to list transactions for all accounts, leave both this field and the field beginning in position 25 blank.

7. Code the last account you want to list transactions for in the field beginning in position 25. If you want only one account listed, leave this field blank.

THIS COMPLETES THE FORM

METER READING DOCUMENT REQUEST FORM

C	M

1

ACTIVITY CODE

3

Field	Route (column)	Scheduled Read Date (column)
ROUTE / SCHEDULED READ DATE	9	11
ROUTE / SCHEDULED READ DATE	17	19
ROUTE / SCHEDULED READ DATE	25	27
ROUTE / SCHEDULED READ DATE	33	35
ROUTE / SCHEDULED READ DATE	41	43
ROUTE / SCHEDULED READ DATE	49	51
ROUTE / SCHEDULED READ DATE	57	59
ROUTE / SCHEDULED READ DATE	65	67

Instructions for Completing the Meter Reading Document Request Form

1. To request Meter Reading Documents with pre-printed data.

   a. Fill in the Activity Code block.
   b. Enter the route number of meter reading documents required.
   c. Enter the projected read date for the route in the block marked 'Scheduled Read Date'. The Date is in the format Year Year, Month Month, Day Day; e.g. 2 January 1978 would be entered as "780102".
   d. If all routes at an activity are to be printed with the same projected read date, enter "99" for the route number and the projected read date as described in paragraph c, above.

2. To request Blank Meter Reading Documents.

   a. Fill in the Activity Code block.
   b. Enter "00" for route number.
   c. Enter the number of blank documents required in the block marked "Scheduled Read Date".

When Blank Meter Reading Documents are requested, the request must be the first entry on the form.

FAMILY HOUSING MOCK UTILITY BILLING SYSTEM

REPORT REQUEST

Transaction code	1 [R]	2 [ ]	Type code
Activity	3 [ ][ ][ ][ ][ ][ ]		
File to print	21 [ ][ ][ ][ ][ ][ ][ ]		

Instructions for Completing the FH/MUBS Report Request

1. Begin at the left-most box for all fields.

2. Enter the activity code starting in position 3.

TO REQUEST THIS REPORT:	ENTER THESE PARAMETERS
a. Period Norm Listing (Report No. MB1P4-D)	1. "a" in position 2. 2. "P-NORM" in position 21.
b. FH/MUBS Activity Master Listing (Report No. MB1P4-B)	1. "a" in position 2. 2. "WEATHER" in position 21.
c. FH/MUBS Account Number Ordered Listing (Report No. MB1P4-A)	1. "a" in position 2. 2. 'NORM' in position 21.
d. Account Number/Address Cross Reference List (Report No. MB1P3-A)	1. "b" in position 2. 2. "NORM" in position 21.

METER READING DOCUMENT

SEQ:

SERVICE PERIOD ROUTE:

FROM TO

ACCT:

METER: PLACEMENT: BLDG NO:

HI:

PREVIOUS: MASTER METER NO:

LO:

CURRENT READING I_I_I_I_I_I_I_I

VERIFICATION I_I

TYPE OF READING I_I

READER CODE I_I_I

DATE OF READING I_I_I_I_I_I_I

NEW SEQ NUMBER I_I_I_I

****

METER READING DOCUMENT

ADDR: SEQ:

SERVICE PERIOD ROUTE:

FROM TO

ACCT:

METER: PLACEMENT: BLDG NO:

HI:

PREVIOUS: MASTER METER NO:

LO:

CURRENT READING I_I_I_I_I_I_I_I

VERIFICATION I_I

TYPE OF READING I_I

READER CODE I_I_I

DATE OF READING I_I_I_I_I_I_I

NEW SEQ NUMBER I_I_I_I

METER READING DOCUMENT

ADDR: 1456 Alabama Ave — SEQ: 143

SERVICE PERIOD — ROUTE: 2

FROM TO

780517 780615

METER: A 1923 G 9 PLACEMENT: 42 BLDG NO: 1456

HI: 4339

PREVIOUS: 3353

LO: 3586

CURRENT READING: 3929 — VERIFICATION

TYPE OF READING — READER CODE: 05 — DATE OF READING

NEW SEQ NUMBER

METER READING DOCUMENT

1456A Alabama Ave — SEQ: 14_

SERVICE PERIOD — ROUTE: 24

FROM TO

ACCT: 123456-01 780517 780615

METER: A 2100 G 0 PLACEMENT: 40 BLDG NO: 1456A

HI: 6915

PREVIOUS: 6110 MASTER METER NO: A 1923 G 9

LO: 6375

CURRENT READING: 6500 — VERIFICATION

TYPE OF READING — READER CODE: 05 — DATE OF READING

NEW SEQ NUMBER

METER READING DOCUMENT

1876C Virginia Ave

SEQ: 145
ROUTE: 24

SERVICE PERIOD
FROM TO
780528 ~~780615~~

ACCT: 123558-02

METER: A 5900 GO PLACEMENT: 43 BLDG NO: 1876C

HI: 6200
PREVIOUS: 5586
LO: 5710

CURRENT READING: 6295 VERIFICATION: V

TYPE OF READING: READER CODE: 05 DATE OF READING: 780616

NEW SEQ NUMBER:

METER READING DOCUMENT

SEQ:
ROUTE:

SERVICE PERIOD
FROM TO

ACCT: 123333

METER: A 325250 PLACEMENT: BLDG NO:

HI:
PREVIOUS: MASTER METER NO: A 258859
LO:

CURRENT READING: 8765 VERIFICATION:

TYPE OF READING: E READER CODE: 05 DATE OF READING: 780610

NEW SEQ NUMBER:

FAMILY HOUSING MOCK UTILITY BILLING

Meter Reading Document Transaction Register

REPORT NO: MB1P6-A DATE:

ACTIVITY:

ACCOUNT	METER NUMBERS	DATE READ	READ TYPE	READING	READING VERIFIED	READER CODE
999999-99	X 9999 X 9	YY MM DD	X	9999999	X	99
	X 9999 X 9	YY MM DD	X	9999999		99
999999-99	X 9999 X 9	YY MM DD	X	9999999	X	99

NUMBER OF ACCOUNTS READ	NUMBER OF METERS AT ACCOUNTS	TOTAL METERS READ	READINGS MISSING
99,999	99,999	99,999	999

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FAMILY HOUSING MOCK UTILITY BILLING

```
REPORT NO:  MB1P6-B                                                                        DATE:

ACTIVITY:                          METER DOCUMENT EDIT LIST                                PAGE:


X      ERROR MESSAGE      X
X      ERROR MESSAGE      X


MX XXXXXX XXXXXX XX XXXXXXX XXXXXXX 9999999 999999 X X 999 XX


X      ERROR MESSAGE      X

MX XXXXXX XXXXXX XX XXXXXXX XXXXXXX 9999999 999999 XXX 999 XX
```

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FAMILY HOUSING MOCK UTILITY BILLING

REPORT NO: MB1P1-B   DATE:

ACTIVITY: CUSTOMER RECEIPTS REGISTER   PAGE:

CODE:

ACCT/OCCUPANT	BILLING DATE	AMOUNT RECEIVED	ACCT/OCCUPANT	BILLING DATE	AMOUNT RECEIVED
999999-99	YY MM DD	$9,999.99	999999-99	YY MM DD	$9,999.99
999999-99	YY MM DD	$9,999.99	999999-99	YY MM DD	$9,999.99
999999-99	YY MM DD	$9,999.99	999999-99	YY MM DD	$9,999.99

RECEIPTS SUMMARY

9,999 RECEIPTS RECEIVED FOR A TOTAL OF $9,999 DOLLARS.

THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974.

```
                              FAMILY HOUSING MOCK UTILITY BILLING
REPORT NO:  MB1P1-A                 ACCOUNT FILE TRANSACTION LIST                        DATE:
ACTIVITY:                                                                                PAGE:

12  ABCDEF  78123  999 999 99 99
13  ABCDEF  78121  999

D2  ABCDEF  999999 99 NA XXXXXXXXXXXXXXXXXXXX MI                         999999 DE     99
D3  ABCDEF  999999 99 BA XXXXXXXXXXXXXXXXXXXX BB XXXXXXXXXXXXXXXXXXXX
D3  ABCDEF  999999 99 BC XXXXXXXXXXXXXXXXXXXX RK XXXX                          GR   XXX
Z2  ABCDEF  X99999 999999 MN X9999XX BN XXXXXX MS XXXXXXXX NP 99 RC 99999 RD 999999
Z3  ABCDEF  X99999 999999 MN X9999XX RN 99 SQ 999 CA X
Z3  ABCDEF  X99999 999999 MN X9999XX RC 999 CA X
```

FAMILY HOUSING MOCK UTILITY BILLING

REPORT NO.: MB1P1-C DATE:

ACTIVITY: METER DATA ERROR LIST PAGE:

X ERROR MESSAGE X
X ERROR MESSAGE X

2X XXXXXX XXXXXX XX XXXXXXX XXXXXXX 9999999 999999 X X 999 XX

X ERROR MESSAGE X

2X XXXXXX XXXXXX XX XXXXXXX XXXXXXX 9999999 999999 X X 999 XX

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FAMILY HOUSING MOCK UTILITY BILLING

REPORT NO. MB1P1-D DATE:

ACTIVITY: OCCUPANT DATA ERROR LIST PAGE:

ERROR MESSAGE

```
DX 999999 99 XX XXXXXXXXXXXXXXXXXXXX XX XXXXXXXXXXXXXXXXXXXX XX XXXXXXX
```

ERROR MESSAGE
ERROR MESSAGE

```
DX 999999 99 XX XXXXXXXXXXXXXXXXXXXX XX XXXXXXXXXXXXXXXXXXXX XX XXXXXXX
```

Account No.

TO:

D.9

MILITARY FAMILY HOUSING UTILITY BILLING TEST

Acct.#: Bill Date: Days Billed:
Meter Number: Curr. Read Date: Prior Read Date:

1. *Utility/Measurement*
2. Current Reading
3. Prior Reading
4. Usage
5. Norm
6. Variance
7. Cost of Total Usage
8. Cost of Norm
9. Cost of Excess Usage
10. Total Cost of Excess Usage
11. Unpaid Balance
12. This is a Test. **DO NOT PAY NEW BALANCE OF:**

REPORT NO: MB1P8-R

ACTIVITY:

CODE:

DATE:

PAGE:

CUSTOMER BILLING REGISTER

ACCOUNT	DAYS BILLED	UTILITY	CURRENT READING	PRIOR READING	ACTUAL USAGE (U/M)	NORM USAGE	VARIANCE	ACTUAL COST	NORM COST	VARIANCE COST
999999-99	99	XXXX	9999999	9999999	9999999 XXX	9999999	999999	$9,999.99	$9,999.99	$9,999.99
		XXXX	9999999	9999999	9999999 XXX	9999999	999999	$9,999.99	$9,999.99	$9,999.99
							TOTAL VARIANCE:		$9,999.99	$9,999.99
							UNPAID BALANCE:		$9,999.99	$9,999.99
							TOTAL BILL:		$9,999.99	$9,999.99

ACTIVITY DOLLAR SUMMARY

	CUSTOMERS	FAMILY HOUSING	LINE TOTAL
ELECTRICITY	$ 999,999.99	$ 999,999.99	$ 999,999.99
NATURAL GAS	$ 999,999.99	$ 999,999.99	$ 999,999.99
FUEL OIL	$ 999,999.99	$ 999,999.99	$ 999,999.99
STEAM HEAT	$ 999,999.99	$ 999,999.99	$ 999,999.99
HOT WATER HEAT	$ 999,999.99	$ 999,999.99	$ 999,999.99
PROPANE	$ 999,999.99	$ 999,999.99	$ 999,999.99
**ARREARS	$ 999,999.99	$ 999,999.99	$ 999,999.99
COLUMN TOTAL	$99,999,999.99	$99,999,999.99	$99,999,999.99

ACCOUNT SUMMARY

	NUMBER OF CUSTOMERS	NUMBER OF COMMON USAGE
BILLED THIS CYCLE	999,999	999,999

THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974.

FAMILY HOUSING MOCK UTILITY BILLING

REPORT NO: MB1P8-C

DATE:

ACTIVITY:

FAMILY HOUSING ACCOUNT REPORT

PAGE:

CODE:

ACCOUNT	DAYS BILLED	UTILITY	CURRENT READING	PRIOR READING	ACTUAL USAGE (U/M)	ACTUAL COST
999999-FH	99	XXXX	9999999	9999999	9999999 XXX	$ 99,999.99
999999-FH	99	XXXX	9999999	9999999	9999999 XXX	$ 99,999.99
					TOTAL ACTUAL COST	$999,999.99

REPORT NO: MB1P4-A FAMILY HOUSING MOCK UTILITY BILLING SYSTEM DATE: 06/02/78

ACTIVITY: PWC GREAT LAKES, IL ACCOUNT NUMBER ORDERED LISTING PAGE: 1

BUILDING NUMBER:	1004	ACCOUNT NUMBER:	005000	ADDRESS:	1004 POLARIS DR	ACTIVE CUST POINTER:	01
NUMBER OF BEDROOMS:	4	FLOOR AREA:	3003	BUILDING VOLUME:	28780	WINDOW AREA	751
HOT WATER FUEL:	G	COOKING FUEL:	E	HOT WATER PILOTS:	2	RANGE PILOTS:	0
DRYER PILOTS:	0	FURNACE PILOTS:	2	AIR CONDITIONER PILOTS:	0	HEATING FUEL:	G
COOLING FUEL:		AVG DLY ELEC OUTSIDE	0	AVG DLY GAS OUTSIDE:	0	AVG DLY OIL OUTSIDE:	0
AVG DLY STEAM OUTSD:	0	AVG DLY HOT H2O OUT	0	AVG DLY CLD H2O OUT	0	CONSTRUCTION TYPE:	M
YEAR BUILT:	58	WEATHER STRIPPING:	N	STORM DOOR FLAG:	N	HOME STYLE:	S
HORIZONTAL CONF:		VERTICAL CONF:		NUMBER OF STORIES:	1	BASEMENT TYPE:	S
ATTIC:	Y	INFILTRATION FAC:	999999	INTERNAL GAIN:	9999.99999	BUILDING MASS:	9999.99999
SET POINT:	9.99	FURNACE EFFICIENCY:	9.99	HOT WATER EFF:	9.99	COOLING SYS EFF:	9.99
COOLING SYS COEFF:	9.99	INFILTRATION LOAD:	9999.9999	SOLAR LOAD FACTOR:	9999.9999	INTERNAL LOAD LEV:	9999.9999
AIR CHANGE RATE:	9.990	HEATING FAN FACTOR:	.000000	COOLING FAN FACTOR:	.000000	# OCCUPANTS:	04

BUILDING NUMBER:	1000	ACCOUNT NUMBER:	005001	ADDRESS:	1000 POLARIS DR	ACTIVE CUST POINTER:	01
NUMBER OF BEDROOMS:	4	FLOOR AREA:	1870	BUILDING VOLUME:	15110	WINDOW AREA	299
HOT WATER FUEL:	G	COOKING FUEL:	E	HOT WATER PILOTS:	1	RANGE PILOTS:	0
DRYER PILOTS:	0	FURNACE PILOTS:	1	AIR CONDITIONER PILOTS:	0	HEATING FUEL:	G
COOLING FUEL:		AVG DLY ELEC OUTSIDE	0	AVG DLY GAS OUTSIDE:	0	AVG DLY OIL OUTSIDE:	0
AVG DLY STEAM OUTSD:	0	AVG DLY HOT H2O OUT	0	AVG DLY CLD H2O OUT	0	CONSTRUCTION TYPE:	M
YEAR BUILT:	58	WEATHER STRIPPING:	N	STORM DOOR FLAG:	N	HOME STYLE:	S
HORIZONTAL CONF:		VERTICAL CONF:		NUMBER OF STORIES:	1	BASEMENT TYPE:	S
ATTIC:	Y	INFILTRATION FAC:	999999	INTERNAL GAIN:	9999.99999	BUILDING MASS:	9999.99999
SET POINT:	9.99	FURNACE EFFICIENCY:	9.99	HOT WATER EFF:	9.99	COOLING SYS EFF:	9.99
COOLING SYS COEFF:	9.99	INFILTRATION LOAD:	9999.9999	SOLAR LOAD FACTOR:	9999.9999	INTERNAL LOAD LEV:	9999.9999
AIR CHANGE RATE:	9.990	HEATING FAN FACTOR:	.000000	COOLING FAN FACTOR:	.000000	# OCCUPANTS:	07

BUILDING NUMBER:	1001	ACCOUNT NUMBER:	005002	ADDRESS:	1001 POLARIS DR	ACTIVE CUST POINTER:	01
NUMBER OF BEDROOMS:	4	FLOOR AREA:	1567	BUILDING VOLUME:	12661	WINDOW AREA	248
HOT WATER FUEL:	G	COOKING FUEL:	E	HOT WATER PILOTS:	1	RANGE PILOTS:	0
DRYER PILOTS:	0	FURNACE PILOTS:	1	AIR CONDITIONER PILOTS:	0	HEATING FUEL:	G
COOLING FUEL:		AVG DLY ELEC OUTSIDE	0	AVG DLY GAS OUTSIDE:	0	AVG DLY OIL OUTSIDE:	0
AVG DLY STEAM OUTSD:	0	AVG DLY HOT H2O OUT	0	AVG DLY CLD H2O OUT	0	CONSTRUCTION TYPE:	M
YEAR BUILT:	58	WEATHER STRIPPING:	N	STORM DOOR FLAG:	N	HOME STYLE:	S
HORIZONTAL CONF:		VERTICAL CONF:		NUMBER OF STORIES:	1	BASEMENT TYPE:	S
ATTIC:	Y	INFILTRATION FAC:	999999	INTERNAL GAIN:	9999.99999	BUILDING MASS:	9999.99999
SET POINT:	9.99	FURNACE EFFICIENCY:	9.99	HOT WATER EFF:	9.99	COOLING SYS EFF:	9.99
COOLING SYS COEFF:	9.99	INFILTRATION LOAD:	9999.9999	SOLAR LOAD FACTOR:	9999.9999	INTERNAL LOAD LEV:	9999.9999
AIR CHANGE RATE:	9.990	HEATING FAN FACTOR:	.000000	COOLING FAN FACTOR:	.000000	# OCCUPANTS:	07

[redacted] [redacted]

```
REPORT ID: MBIP1-E                          Norm Data Error List                                05/01/78
ACTIVITY  PWC GREAT LAKES, IL                                                                    PAGE

>>>> W ACCOUNT ALREADY EXISTS
>>>>
     3 2 N65113 000123 001004 101 BOMARC            02 1 0800 06400 080 D E 0 0 0 0 0 0
>>>> W ACCOUNT ALREADY EXISTS
>>>>
     4 2 N65113 000123 001004 003 000000 014000 006000 000000 000000 B 67 Y Y S     1 C Y
>>>> W ACCOUNT ALREADY EXISTS
>>>>
     5 2 N65113 000123 001004 010133 003 10 95 70 80 000 00 00 000 00 041 000006 000000
>>>> W ACCOUNT ALREADY EXISTS
>>>>
     3 2 N65113 345689 001006 205A DECKER ST        05 4 2100 16800 210 S E 0 0 0 0 0 0 S S
>>>> W ACCOUNT ALREADY EXISTS
>>>> F INCONSISTENT DATA ITEMS
>>>>                                                                               X
     4 2 N65113 345689 001006 001 000000 000000 015000 003000 000000 C 61 Y Y T E T 1  Y
>>>> W ACCOUNT ALREADY EXISTS
>>>>
     5 2 N65113 345689 001006 024600 004 16 89 95 95 280 95 14 430 81 065 000000 000008
>>>> W ACCOUNT ALREADY EXISTS
>>>>
     3 2 N65113 981A   001007 981A STREETOR         03 2 1100 09900 210 H E 0 0 0 0 0 H F
>>>> W ACCOUNT ALREADY EXISTS
>>>>
     4 2 N65113 981A   001007 000 000000 000000 000000 000000 000000 F 76 Y N S     1 C Y
>>>> W ACCOUNT ALREADY EXISTS
>>>> F ALLOWABLE RANGE 0 TO 2
>>>>
     5 2 N65113 981A   001007 018473 002 16 78 95 95 280 95 14 430 78 990 000006 000008
>>>> W ACCOUNT ALREADY EXISTS
>>>> F ALLOWABLE VALUES 0 , 3
>>>>
     3 2 N65113 678    001008 1200 WASHINGTON       05 3 1800 14400 140 G G 1 5 1 1  G E
```

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THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974

[redacted] [redacted]

REPORT NO: MB1P4-B

ACTIVITY: ANY ACTIVITY

FAMILY HOUSING NCK UTILITY BILLING SYSTEM

ACTIVITY MASTER LISTING

DATE: 05/10/78

PAGE: 1

JULIAN DATE	HEATING DEGREE DAYS	COOLING HOURS	AVG WATER TEMP	COOLING DEGREE DAYS
001	99	99	99	99
002	99	99	99	99
003	99	99	99	99
004	99	99	99	99
005	99	99	99	99
006	99	99	99	99
007	99	99	99	99
008	99	99	99	99
009	99	99	99	99
010	99	99	99	99
011	99	99	99	99
012	99	99	99	99
013	99	99	99	99
014	99	99	99	99
015	99	99	99	99
016	99	99	99	99
017	99	99	99	99
018	99	99	99	99
019	99	99	99	99
020	99	99	99	99
021	99	99	99	99
022	99	99	99	99
023	99	99	99	99
024	99	99	99	99
025	99	99	99	99
026	99	99	99	99
027	99	99	99	99
028	99	99	99	99
029	99	99	99	99
030	99	99	99	99
031	99	99	99	99
032	99	99	99	99
033	99	99	99	99
034	99	99	99	99
035	99	99	99	99
036	99	99	99	99
037	99	99	99	99
038	99	99	99	99
039	99	99	99	99
040	99	99	99	99
041	99	99	99	99
042	99	99	99	99
043	99	99	99	99
044	99	99	99	99
045	99	99	99	99
046	99	99	99	99
047	99	99	99	99

FAMILY HOUSING MOCK UTILITY BILLING

REPORT NO: MB1P3-A   DATE:

ACTIVITY: ACCOUNT/ADDRESS CROSS REFERENCE LIST   PAGE:

ACCOUNT	ADDRESS	ACCOUNT	ADDRESS
999999	XXXXXXXXXXXXXXXXXXX	999999	XXXXXXXXXXXXXXXXXXX
999999	XXXXXXXXXXXXXXXXXXX	999999	XXXXXXXXXXXXXXXXXXX
999999	XXXXXXXXXXXXXXXXXXX	999999	XXXXXXXXXXXXXXXXXXX
999999	XXXXXXXXXXXXXXXXXXX	999999	XXXXXXXXXXXXXXXXXXX
999999	XXXXXXXXXXXXXXXXXXX	999999	XXXXXXXXXXXXXXXXXXX

THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO
THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974

FAMILY HOUSING MOCK UTILITY BILLING

REPORT NO: MB1P9-A | DATE:

ACTIVITY: | AUDIT TRAIL REPORT | PAGE:

FROM YYDDD TO YYDDD

TRANS CODE	ACTY CODE				JULIAN DATE
XX	XXXXXX	XXXX	XXXX	XXXX	99999
XX	XXXXXX	XXXX	XXXX	XXXX	99999
XX	XXXXXX	XXXX	XXXX	XXXX	99999
XX	XXXXXX	XXXX	XXXX	XXXX	99999
XX	XXXXXX	XXXX	XXXX	XXXX	99999
XX	XXXXXX	XXXX	XXXX	XXXX	99999

THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974.

REPORT NO: MB1P4-C FAMILY HOUSING MOCK UTILITY BILLING SYSTEM DATE: 06/01/78

ACTIVITY: ANY ACTIVITY PERIOD NORM LISTING PAGE: 1

ACCOUNT	GAS	ELECTRIC	OIL	STEAM	H.WATER	C.WATER
001002	241	22383	0	0	0	0
001003	144	146	0	0	0	0
001005	170	90	0	0	0	0
001001	455	214	0	0	0	0
001006	0	371	0	2065	0	0
001007	0	493	0	0	1357	0
001010	1288	335	0	0	0	0

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MONTHLY ENERGY CONSUMPTION REPORT

REPORT NO: MB3P10-A

ACTIVITY NAME: PWC Outer Banks, FL   CATEGORY OF QUARTERS: B   DATE OF REPORT: ______

ACCOUNT NO.	ADDRESS	PAY GRADE	OCC DAYS	VAC DAYS	UTIL	USAGE	NORM	VAR	SAVINGS	EXC CHARGE
021740	31A Bluebird Lane	003	30	0						
	Occupied Usage				E	568	478	+90		$3.60
					G	114	110	+4		$1.16
					TOTAL					$4.76
021744	33B Bluebird Lane	001	30	0						
	Occupied Usage				E	612	490	+122		$4.88
					G	98	190	-11	$3.19	
					TOTAL				$3.19	$4.88
021896	1942 Aspen Road	E07	28	2						
	Occupied Usage				E	447	467	-20	$ .80	
					G	108	103	+5		$1.45
	Vacant Usage				E	23				
					G	5				
					TOTAL				$ .80	$1.45
021900	1947 Aspen Road	E08	25	5						
	Occupied Usage				E	428	403	+25		$1.00
					F	195	187	+8		$3.76
	Vacant Usage				E	60				
					F	21				
					TOTAL					$4.76

Summary for: Qtrs B

Total of Excess Usage Charges:	$15.85	Total Occupied Usage:		Total Vacant Usage:	
No. of Incidents of Excess Charges:	6	E	2055	E	83
		G	320	G	5
Total Savings:	$3.99	F	195	F	21
No. of Incidents of Savings:	2				

THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974.

REPORT NO: MB3P10-A

MONTHLY ENERGY CONSUMPTION REPORT

ACTIVITY NAME: PWC Outer Banks, FL   CATEGORY OF QUARTERS: Summary   DATE OF REPORT: ________

ACCOUNT NO.	ADDRESS	PAY GRADE	OCC DAYS	VAC DAYS	UTIL	USAGE	NORM	VAR.	SAVINGS	EXC CHARGE

Summary for: Activity

Total of Excess Usage Charges:	$439.10
No. of Incidents of Excess Charges:	175
Total Savings:	$277.84
No. of Incidents of Savings:	133

Total Occupied Usage:

E	586,235
G	300,128
F	10,899
S	435,622

Total Vacant Usage:

E	868
G	532
F	140
S	385

QUARTERLY ENERGY CONSUMPTION REPORT

Report No: MB3P11-A

Activity Name ________ Activity UIC ________ Date of Report ________

Cat. of Qtrs.	Type of Utility	Usage	1st Period	2nd Period	3rd Period	1st Qtr Total
—	Electricity (KWH)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Gas (CCF)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Electricity (KWH)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Oil (Gal)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				

Report No: MB3P11-A

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ____________ **Activity UIC** ____________ **Date of Report** ____________

Cat. of Qtrs.	Utility	Usage	1st Period	2nd Period	3rd Period	1st Qtr Total
Total Unit Consumption						
	Electricity (KWH)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Gas (CCF)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Oil (Gal)	Actual Occupied				
		Norm				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				

INCLUDE "COMMON USE"

Report No: MB3P12-A

DELINQUENT ACCOUNTS

Activity Name PWC Outer Banks, FL

Date of Report ____________

Account No.	Name	PAY GRADE	Address	31-60 Days	61-90 Days	Over 90 Days	Total Arrears
020644	Edward R. Abrahms	003	1306 Aspen Ct.	6.45			6.45
020992	Paul G. Corey	E04	231 Nuggett La.			3.96	3.96
021385	Warren T. Davies	001	46 Wayside Drive		2.84	11.17	14.01
021517	Gerald R. Franks	E07	550 Browns St.	7.13			7.13
022005	Dolores M. Smythe	E05	137 Kraft Rd.		22.85		22.85
Number of Accounts in Arrears	5						
Grand Total in Arrears				13.58	25.69	15.13	54.40

THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO THE SAFEGUARD PROVISIONS OF THE PRIVACY ACT OF 1974.

Consumption Within Norm

QUARTERLY ~~ENERGY SAVINGS~~ REPORT

Report No: MB3P13-A

Activity Name PWC Outer Banks, FL   Activity UIC N99999   Date of Report 3 Apr 1978

Category of Quarters	Type of Utility	No. of Incidents Within Norm	Amount Energy ~~Saved~~ Within Norm	~~Dollars~~ Saved Value of Energy Within Norm
A	Elec	25	238 KWH	14.28
A	Gas	12	212 CUFT (100)	81.71
B	Elec	83	613 KWH	36.78
B	Oil	0	0 GAL	0

CONSUMPTION WITHIN NORM

QUARTERLY ~~ENERGY SAVINGS~~ REPORT

Report No: MB3P13-A

Activity Name PWC Outer Banks, FL   Activity UIC N99999   Date of Report 3 Apr 1978

Category of Quarters	Type of Utility	No. of Incidents Within Norm	Amount of Energy ~~Saved~~ Within Norm	~~Dollars~~ Value of Energy ~~Saved~~ Within Norm
All	Elec	108	851 KWH	51.06
All	Gas	12	212 CUFT (100)	81.71
All	Oil	0	0	0
TOTAL SAVINGS				132.77

D

METER INVENTORY

Report No: MB3P14-A
Activity Name ______________

Date of Report ______________

Meter Serial Number	Type of Meter	Date of Receipt	Location

FACSO SOURCE DATA CONVERSION PROCEDURE
IND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME	WEATHER DATA INPUT	
SOURCE NAME AND NUMBER	ACTIVITY WEATHER LOG	
STROKES	30	☐ ON ☐ OFF
		5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	-	WEATHER LOG		N	Y	1	PUNCH '1'
2	-	TYPE OF WEATHER TRANS.		N	Y	1	AS SHOWN
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	20	SPACES	S			12	
21	25	JULIAN DATE		N	Y	5	AS SHOWN, LEFT ZERO
26	28	HIGH TEMPERATURE		N	Y	3	LEFT ZERO. '11' OVERPUNCH IN LOW-ORDER POSITION IF MINUS SIGN APPEARS TO LEF OF FIELD
29	31	LOW TEMPERATURE		N	Y	3	LEFT ZERO. '11' OVERPUNCH LOW ORDER POSITION IF A MINUS SIGN APPEARS TO LEF OF FIELD
32	33	COOLING HOURS		N	Y	2	LEFT ZERO, ZERO IF SPACES
34	36	WATER TEMPERATURE		N	Y	3	LEFT ZERO, ZERO IF SPACES
37	75	SPACES	S				
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

APPROVED BY (NAME & CODE) | DATE | DISPOSITION OF OUTPUT | SHEET OF

32 Fields Available if Only Main is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
11ND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME	NORM DATA CORRECTION
SOURCE NAME AND NUMBER	NORM DATA CHANGES/ CORRECTIONS FORM
STROKES	73
	5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		N	Y	2	PUNCH '33'
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT #		N	Y	6	LEFT ZERO
15	20	BLDG #		AN	Y	6	AS SHOWN, SPACE RIGHT
21	22	FIELD		A	Y	2	AS SHOWN
23	42	CHANGE TO		AN	Y	20	AS SHOWN, SPACE RIGHT
43	44	FIELD		A	Y	2	AS SHOWN
45	50	CHANGE TO		AN	Y	6	AS SHOWN, SPACE RIGHT
51	52	FIELD		A	Y	2	AS SHOWN
53	58	CHANGE TO		AN	Y	6	AS SHOWN, SPACE RIGHT
59	60	FIELD		A	Y	2	AS SHOWN
61	66	CHANGE TO		AN	Y	6	AS SHOWN, SPACE RIGHT
67	75	SPACES	S			9	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING

32 Fields Available if Only Main Is Used-16 Fields Available Each. When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
(IND-CBC-5235/38 (4-74)
0900-223-5381

PROCEDURE NAME	ACTIVITY FUEL CONTENT
SOURCE NAME AND NUMBER	FH/MUBS FUEL CONTENT CHANGES
STROKES	35
	5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		N	Y	2	PUNCH '63'
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	20	SPACES	S			12	
21	25	B.t.u.'s/ft^3 OF GAS		N	Y	5	LEFT ZERO
26	32	B.t.u.'s/gal OF OIL		N	Y	7	LEFT ZERO
33	37	SPACES	S			5	
38	42	B.t.u.'s/lb OF PROPANE		N	Y	5	LEFT ZERO
43	75	SPACES	S			33	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main Is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
1IND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME: RATE DATA CHANGE

SOURCE NAME AND NUMBER: FAMILY HOUSING MOCK BILLING RATE FORM

STROKES: 22

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		A	Y	2	PUNCH "RU"
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	SPACES	S			6	
15	-	ENERGY CODE		A	Y	1	AS SHOWN
16	-	RATE #		N	Y	1	PUNCH "1"
17	23	UNIT RATE		N	Y	7	AS SHOWN
24	39	SPACES	S			16	
40	45	EFFECTIVE DATE		N	Y	6	AS SHOWN
46	75	SPACES	S			30	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

APPROVED BY NAME & CODE | DATE | DISPOSITION OF OUTPUT | SHEET

32 Fields Available if Only Main Is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME	FH/MUBS OCCUPANCY DATA
SOURCE NAME AND NUMBER	FH/MUB OCCUPANT CHECK-IN SHEET (FIRST CARD)
STROKES	48
	5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		A	Y	2	PUNCH 'D2'
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6	LEFT ZERO
15	16	SPACES	S			2	
17	18	FIELD		A	Y	2	PUNCH 'NA'
19	34	OCCUPANT NAME		A	Y	16	AS SHOWN
35	38	SPACES	S			4	
39	40	FIELD		A	Y	2	PUNCH 'MI'
41	54	SPACES	S			14	
55	60	MOVE-IN DATE		N	Y	6	AS SHOWN
61	62	FIELD		A	Y	2	PUNCH 'DE'
63	67	SPACES	S			5	
68	69	DEPENDENTS		N	Y	2	AS SHOWN
70	75	SPACES	S			6	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main Is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IMD-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME: FH/MUBS OCCUPANCY DATA

SOURCE NAME AND NUMBER: FH/MUB OCCUPANT CHECK-IN SHEET (SECOND CARD)

60

5081

POSITIONS FROM	TO	MAIN FIELD HEADINGS						REMARKS
1	2	TRANS/TYPE CODE		A	Y	2		PUNCH 'D3'
3	8	ACTIVITY CODE		AN	Y	6		AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6		LEFT ZERO
15	16	SPACES	S			2		
17	18	FIELD		A	Y	2		PUNCH 'BA'
19	38	MAILING ADDRESS		A	Y	20		AS SHOWN
39	40	FIELD		A	Y	2		PUNCH 'BB'
41	60	MORE ADDRESS			Y	20		AS SHOWN
61	75	SPACES	S			15		
76	80	JULIAN DATE	D	N		5		PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

APPROVED BY (NAME & CODE) | DATE (YR MO DA) | DISPOSITION OF OUTPUT | SHEET OF

32 Fields Available if Only Main Is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME: FH/MUBS OCCUPANCY DATA

SOURCE NAME AND NUMBER: FH/MUBS OCCUPANT CHECK-IN SHEET (THIRD CARD)

55

5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS						REMARKS
1	2	TRANS/TYPE CODE		A	Y	2		PUNCH 'D3'
3	8	ACTIVITY CODE		AN	Y	6		AS SHOWN
9	14	ACCOUNT NUMBER		N	Y	6		LEFT ZERO
15	16	SPACES	S			2		
17	18	FIELD		A	Y	2		PUNCH 'BC'
19	38	MORE ADDRESS		A	Y	20		AS SHOWN
39	40	FIELD		A	Y	2		PUNCH 'RK'
41	44	RANK/RATE		AN	Y	4		AS SHOWN
45	60	SPACES	S			16		
61	62	FIELD		A	Y	2		PUNCH 'GR'
63	65	PAY GRADE		AN	Y	3		AS SHOWN
66	75	SPACES	S			10		
76	80	JULIAN DATE	D	N		5		PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
(IND-CBC-5235/38 (4-74)
0900-223-5381

PROCEDURE NAME: OCCUPANT DATA CORRECTION

SOURCE NAME AND NUMBER: FH/MUB OCCUPANT DATA CHANGE/MAINTENANCE

40

5081

FROM	TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		A	Y	2	PUNCH "D3"
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6	LEFT ZERO
15	16	OCCUPANT		AN	Y	2	AS SHOWN
17	18	FIELD		A	Y	2	AS SHOWN
19	38	CHANGE TO		A	Y	20	AS SHOWN
39	40	FIELD		A	Y	2	AS SHOWN
41	60	CHANGE TO		A	Y	20	AS SHOWN
61	62	FIELD		A	Y	2	AS SHOWN
63	69	CHANGE TO		A	Y	7	AS SHOWN
70	75	SPACES	S			6	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main Is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5233/38 (4-74)
0900-023-5361

PROCEDURE NAME: FH/MUBS OCCUPANCY DATA		60
SOURCE NAME AND NUMBER: FH/MUBS OCCUPANT CHECK-OUT SHEET (FIRST CARD)		5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		AN	Y	2	PUNCH 'D1'
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6	LEFT ZERO
15	16	OCCUPANT #		N	Y	2	AS SHOWN
17	18	FIELD		A	Y	2	PUNCH 'BA'
19	38	FORWARD ADDRESS		AN	Y	20	AS SHOWN
39	40	FIELD		A	Y	2	PUNCH 'BB'
41	60	MORE FORWARD ADDRESS		AN	Y	20	AS SHOWN
61	62	FIELD		A	Y	2	PUNCH 'MO'
63	63	SPACE	S			1	
64	69	MOVE-OUT DATE		N	Y	6	AS SHOWN
70	75	SPACES	S			6	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main Is Used—16 Fields Available Each. When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME	STROKES	
FH/MUBS OCCUPANCY DATA	40	☐ ON ☐ OFF
SOURCE NAME AND NUMBER: FH/MUB OCCUPANT CHECK-OUT SHEET (SECOND CARD)		5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS						REMARKS
1	2	TRANS/TYPE CODE		AN	Y	2		PUNCH 'D3'
3	8	ACTIVITY CODE		AN	Y	6		AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6		LEFT ZERO
15	16	OCCUPANT #		N	Y	2		LEFT ZERO
17	18	FIELD		A	Y	2		PUNCH 'BC'
19	38	MORE FORWARD ADDRESS		AN	Y	20		AS SHOWN
39	75	BLANK	S			37		
76	80	JULIAN DATE	D	N		5		PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
1IND-CBC-5235/38 (4-74)
0900-023-5381

METER DATA LOAD 1

FAMILY HOUSING MOCK BILLING NEW METER DATA FORM

37

5081

POSITIONS FROM	TO	MAIN FIELD HEADINGS						REMARKS
1	2	TRANS/TYPE CODE		AN	Y	2	PUNCH "Z2"
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6	LEFT ZERO
15	16	FIELD		A	Y	2	PUNCH "MN"
17	23	METER NUMBER		AN	Y	7	AS SHOWN
24	24	SPACES		S		1	
25	26	FIELD		A	Y	2	PUNCH "BN"
27	32	BUILDING NO.		AN	Y	6	AS SHOWN
33	34	SPACES		S	Y	2	
35	36	FIELD		A	Y	2	PUNCH "MS"
37	44	METER SERIAL		AN	Y	8	AS SHOWN
45	46	FIELD		A	Y	2	PUNCH "NP"
47	48	PLACEMENT		N	Y	8	AS SHOWN
49	54	SPACES		S	Y	6	
55	56	FIELD		A	Y	2	PUNCH "RC"
57	62	READING CONSTANT		N	Y	6	AS SHOWN
63	64	SPACES		S	Y	2	
65	66	FIELD		A	Y	2	PUNCH "RD"
67	72	RECEIPT DATE		N	Y	8	AS SHOWN
73	75	SPACES		S	Y	3	
76	80	JULIAN DATE		N	Y	5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main Is Used-16 Fields Available Each. When Both Main/Alternate Used

☐ IF X. ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
1IND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME	METER DATA LOAD 2
SOURCE NAME AND NUMBER	FAMILY HOUSING MOCK BILLING NEW METER DATA FORM
STROKES	37
	5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		AN	Y	2	PUNCH "Z3"
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6	LEFT ZERO
15	16	FIELD I.D.		A	Y	2	PUNCH "MN"
17	23	METER NUMBER		AN	Y	7	AS SHOWN
24	24	SPACES		S		1	
25	26	FIELD I.D.		A	Y	2	PUNCH "RN"
27	28	ROUTE NUMBER		N	Y	2	LEFT ZERO
29	34	SPACES		S		6	
35	36	FIELD I.D.		A	Y	2	PUNCH "SQ"
37	39	READING SEQUENCE		N	Y	3	LEFT ZERO
40	44	SPACES		S		5	
45	46	FIELD I.D.		A	Y	2	PUNCH "CA"
47	47	BLDG. CATEGORY		A	Y	1	AS SHOWN
48	75	SPACES		S		28	
76	80	JULIAN DATE		N	Y	5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

32 Fields Available if Only Main is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

PROCEDURE NAME: METER DATA CHANGE

SOURCE NAME AND NUMBER: FAMILY HOUSING MOCK BILLING METER DATA CHANGE FORM

STROKES: 37

CARD: 5081

FROM	TO	MAIN FIELD HEADINGS					REMARKS
1	2	TRANS/TYPE CODE		AN	Y	2	PUNCH "Z3"
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	14	ACCOUNT NUM.		N	Y	6	LEFT ZERO
15	16	FIELD		A	Y	2	PUNCH "MN"
17	23	METER NUMBER		AN	Y	7	AS SHOWN
24	24	SPACE		S		1	
25	26	FIELD		A	Y	2	AS SHOWN
27	34	CHANGE TO		AN	Y	8	AS SHOWN
35	36	FIELD		A	Y	2	AS SHOWN
37	44	CHANGE TO		AN	Y	8	AS SHOWN
45	46	FIELD		A	Y	2	AS SHOWN
47	54	CHANGE TO		AN	Y	8	AS SHOWN
55	56	FIELD		A	Y	2	AS SHOWN
57	64	CHANGE TO		AN	Y	8	AS SHOWN
65	66	FIELD		A	Y	2	AS SHOWN
67	74	CHANGE TO		AN	Y	8	AS SHOWN
75	75	SPACE		S		1	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

APPROVED BY (NAME & CODE) | DATE (YR MO DA) | DISPOSITION OF OUTPUT | SHEET OF

32 Fields Available if Only Main Is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
1IND-CBC-5235/38 (4-74)
0900-023-5381

KEY TO DISK	FORMAT NO	EFFECTIVE DATE	REV NO	PROCEDURE NAME	PROCEDURE NUMBER
	BATCH RANGE	CUST CODE		METER READING DOCUMENT	STROKES 50 / KP PRINT ☐ ON ☐ OFF
	DS NAME	RETRO		SOURCE NAME AND NUMBER: METER READING DOCUMENT	# LGTH / CARD FORM/COLOR 5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS	SKIP/DUP	CHAR DESC	VERIFY	LENGTH	SOURCE REF	REMARKS
1	2	TRANS/TYPE CODE		A	Y	2		PUNCH "MR"
3	8	ACTIVITY CODE		AN	Y	6		
9	16	ACCT		N	Y	8		① AS SHOWN, OMIT BLAN
17	23	METER		AN	Y	7		② AS SHOWN
24	29	READ DATE		N	Y	6		③ PUNCH FROM "DATE OF R ING" IF FILLED IN, ELSE PUNCH FROM "SERVICE PER TO" DATE
30	36	CURRENT READING		N	Y	7		④ LEFT ZERO
37	37	VERIFICATION		A	Y	1		⑤ AS SHOWN
38	44	MASTER METER NO.		AN	Y	7		⑥ AS SHOWN, SPACE RIGHT
45	45	TYPE OF READING		A	Y	1		⑦ AS SHOWN
46	47	READER CODE		N	Y	2		⑧ AS SHOWN
48	50	NEW SEQ NUMBER		N	Y	3		⑨ AS SHOWN, LEFT ZERO
51	80	JULIAN DATE	D	N		5		PUNCH 5 DIGIT JULIAN DAT CORRESPONDING TO DATE OF KEYPUNCHING.

51-57 BILLABLE WATTS (G.L/BEM)
76-80 JUL. DATE

○ - See source document attached.

APPROVED BY (NAME & CODE)	DATE (YR MO DA)	DISPOSITION OF OUTPUT	SHEET OF

32 Fields Available if Only Main is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

METER READING DOCUMENT

ADDR: SEQ:

SERVICE PERIOD ROUTE:

(1) FROM TO (3)

ACCT:

(2)

METER: PLACEMENT: BLDG NO:

HI:

PREVIOUS: MASTER METER NO: (6)

LO:

(4) (5)

CURRENT READING I_I_I_I_I_I_I_I VERIFICATION I_I

(7) (8) (3)

TYPE OF READING I_I READER CODE I_I_I DATE OF READING I_I_I_I_I_I_I_I

(9)

NEW SEQ NUMBER I_I_I_I

METER READING DOCUMENT

ADDR: SEQ:

SERVICE PERIOD ROUTE:

FROM TO

ACCT:

METER: PLACEMENT: BLDG NO:

HI:

PREVIOUS: MASTER METER NO:

LO:

CURRENT READING I_I_I_I_I_I_I_I VERIFICATION I_I

TYPE OF READING I_I READER CODE I_I_I DATE OF READING I_I_I_I_I_I_I_I

NEW SEQ NUMBER I_I_I_I

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

KEY TO DISK	FORMAT NO	EFFECTIVE DATE	REV NO	PROCEDURE NAME	PROCEDURE NUMBER	FORMAT
	BATCH RANGE		CUST CODE	UTILITY BILL RECEIPT	STROKES 44	AP PRINT ☐ ON ☐ OFF
	DS NAME		RETPD	SOURCE NAME AND NUMBER: UTILITY BILL STUB	R LGTH	CARD FORM/COLOR 5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS	SKIP	DUP	CHAR DESC	VERIFY	LENGTH	SOURCE REF	REMARKS
1	-	TRANSACTION CODE			A	Y	1		PUNCH 'R'
2	-	TYPE CODE			A	Y	1		PUNCH 'R'
3	8	ACTIVITY CODE			AN	Y	6		
9	16	ACCOUNT NUMBER			N	Y	8	1	LEFT ZERO, OMIT SPACE
17	22	SPACES	S				6		
23	28	BILL DATE			N	Y	6	2	AS SHOWN, OMIT SPACES
29	35	...NEW BALANCE OF:			N	Y	7	3	LEFT ZERO, DON'T PUNCH DECIMAL POINT
36	75	SPACES	S				40		
76	80	JULIAN DATE		D	N		5		PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

○ - See source document attached.

APPROVED BY (NAME & CODE)	DATE (YR MO DAY)	DISPOSITION OF OUTPUT	SHEET OF

32 Fields Available if Only Main Is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

MILITARY FAMILY HOUSING UTILITY BILLING TEST

1 Acct.#: 2 Bill Date: Days Billed:
Meter Number: Curr. Read Date: Prior Read Date:

1. Utility/Measurement
2. Current Reading
3. Prior Reading
4. Usage
5. Norm
6. Variance
7. Cost of Total Usage
8. Cost of Norm
9. Cost of Excess Usage
10. Total Cost of Excess Usage
11. Unpaid Balance 3
12. This is a Test. **DO NOT PAY NEW BALANCE OF:**

R E T A I N F O R Y O U R R E C O R D S

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

FORMAT NO.	EFFECTIVE DATE	REV NO.	PROCEDURE NAME	PROCEDURE NUMBER	FOR MAT
			AUDIT TRAIL REQUEST		

Y TO DISK	BATCH RANGE	CUST CODE	SOURCE NAME AND NUMBER	STROKES	KP PRINT
				30	☐ ON ☐ OFF
	DS NAME	RETPD	AUDIT TRAIL REQUEST	R. LGTH	CARD FORM/COLOR
					5081

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS	SKIP/DUP	CHAR DESC	VERIFY	LENGTH	SOURCE REF / REMARKS
1	2	TRANS/TYPE CODE		A	Y	2	PUNCH 'AR'
3	8	ACTIVITY CODE		AN	Y	6	AS SHOWN
9	13	BEGINNING JULIAN DATE		N	Y	5	AS SHOWN
14	18	THRU JULIAN DATE		N	Y	5	AS SHOWN, LEFT ZERO
19	24	BEGINNING ACCOUNT		N	Y	6	AS SHOWN, LEFT ZERO
25	30	END ACCOUNT		N	Y	6	AS SHOWN, LEFT ZERO
31	75	SPACES	S			45	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

APPROVED BY (NAME & CODE)	DATE (YR, MO, DA)	DISPOSITION OF OUTPUT	SHEET OF

32 Fields Available if Only Main is Used-16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

FORMAT NO.	EFFECTIVE DATE	REV NO.	PROCEDURE NAME	PROCEDURE NUMBER	FOR MAT
			METER DOCUMENT CONTROL CARD		
BATCH RANGE	CUST CODE			STROKES	KP PRINT ☐ ON ☐ OFF
			SOURCE NAME AND NUMBER: METER READING DOCUMENT REQUEST FORM		
DS NAME	RETPD			R. LGTH	CARD FORM/COLOR 5081

Y TO DISK

POSITIONS FROM	POSITIONS TO	MAIN FIELD HEADINGS	SKIP/DUP	CHAR DESC	VERIFY	LENGTH	SOURCE REF / REMARKS
1	2	TRANS/TYPE CODE		A	Y	1	PUNCH 'CM'
3	8	ACTIVITY CODE		AN	Y	6	
9	10	ROUTE NUMBER		N	Y	2	LEFT ZERO
11	16	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
17	18	ROUTE NUMBER		N	Y	2	LEFT ZERO
19	24	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
25	26	ROUTE NUMBER		N	Y	2	LEFT ZERO
27	32	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
33	43	ROUTE NUMBER		N	Y	2	LEFT ZERO
35	40	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
41	42	ROUTE NUMBER		N	Y	2	LEFT ZERO
43	48	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
49	50	ROUTE NUMBER		N	Y	2	LEFT ZERO
51	56	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
57	58	ROUTE NUMBER		N	Y	2	LEFT ZERO
59	64	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
65	66	ROUTE NUMBER		N	Y	2	LEFT ZERO
67	72	SCHEDULED READ DATE		N	Y	6	LEFT ZERO
73	75	SPACES	S			3	
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.

APPROVED BY (NAME & CODE)	DATE (YR. MO. DA)	DISPOSITION OF OUTPUT	SHEET OF

32 Fields Available if Only Main is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

FACSO SOURCE DATA CONVERSION PROCEDURE
IIND-CBC-5235/38 (4-74)
0900-023-5381

KEY TO DISK	FORMAT NO	EFFECTIVE DATE	REV NO	PROCEDURE NAME	PROCEDURE NUMBER	FORMAT
				REPORT REQUEST		
	BATCH RANGE	CUST CODE		SOURCE NAME AND NUMBER	STROKES 26	KP PRINT ☐ ON ☐ OFF
	DS NAME	RETPD		FH/MUBS REPORT REQUEST	R. LGTH	CARD FORM/COLOR 5081

POSITIONS FROM	TO	MAIN FIELD HEADINGS	SKIP/DUP	CHAR DESC	VERIFY	LENGTH	SOURCE REF	REMARKS
1	-	TRANS CODE		A	Y	1	PUNCH 'R'	
2	-	TYPE CODE		A	Y	1	AS SHOWN	
3	8	ACTIVITY		AN	Y	6	AS SHOWN	
9	20	SPACES	S					
21	27	FILE TO PRINT		A	Y	7	AS SHOWN	
28	75	SPACES	S			48		
76	80	JULIAN DATE	D	N		5	PUNCH 5 DIGIT JULIAN DATE CORRESPONDING TO DATE OF KEYPUNCHING.	

PREPARED BY (NAME & CODE)	DATE (YR. MO. DA)	DISPOSITION OF OUTPUT	SHEET	OF

[illegible] Fields Available if Only Main is Used—16 Fields Available Each, When Both Main/Alternate Used

☐ IF X, ALTERNATE APPEARS ON REVERSE

F. Job Control Decks

The card decks illustrated below are used to submit data to the billing system via remote job entry stations. Data may be inserted at the indicated position in the proper deck in any order; all types shown for each deck need not be present every time. Transactions placed in the wrong deck will be flagged as errors; data positioned incorrectly in a deck will not be processed and will cause unpredictable results.

1. 'Update Masters'. Use deck below for:

   a. Activity Weather Log ('12', '13')
   b. Norm Data ('31', '32', '33', '42', '52')
   c. Fuel Content Change ('63')
   d. Rate Changes ('RU')
   e. Occupant Data (all 'D's)
   f. Meter Data (all 'Z's)
   g. Utility Bill Receipts ('RR')

```
/*  END OF SORT DATA

INSERT ABOVE
DATA HERE      -->

//SORTIN DD * UPDATE DATA FOLLOWS THIS CARD

//MUB5BP10 JOB NA3001,'UPDATE MASTERS',CLASS=B
```

2. 'Generate Reading Forms'. To submit Meter Reading Document Requests and obtain Meter Reading Documents use the deck below.

```
/*  END OF REQUEST CARDS

INSERT
DATA      -->
HERE

//MTRRQST DD * REQUEST CARDS FOLLOW THIS CARD

//MUB5BP20 JOB NA3001,'GENERATE READING FORMS',CLASS=B
```

3. <u>'Edit Readings'</u>. Use this deck to submit completed and punched meter reading documents.

```
/*  END OF READINGS
```

INSERT
READINGS
HERE →

```
//MTRCARDS DD * READINGS FOLLOW THIS CARD
//MUB5BP30 JOB NA3001,'EDIT READINGS',CLASS=B
```

4. <u>'File Dump'</u>. Use the following deck with the dump control card to obtain a file dump.

```
/*  END OF REQUEST CARDS
```

INSERT
REQUEST
CARD
HERE →

```
//DUMPRQST DD * REQUEST FOLLOW THIS CARD
//MUB5BP40 JOB NA3001,'FILE DUMP',CLASS=B
```

5. 'Cross Reference'. The deck below, with a cross reference control card, will produce an account to service address cross-reference list.

```
/*  END OF REQUEST
```

INSERT
REQUEST
HERE →

```
//XREFRQST DD * REQUEST FOLLOWS THIS CARD
//MUBB5BP50 JOB NA3001,'CROSS REFERENCE',CLASS=B
```

6. 'Audit Trail'. To obtain an audit trail use the deck below and an Audit Trail Request card.

```
/*  END OF REQUESTS
```

INSERT
REQUEST
HERE →

```
//AUDTRQST DD * REQUEST FOLLOW THIS CARD
//MUBB5BP60 JOB NA3001,'AUDIT TRAIL,'CLASS=B
```

REPORT TITLE

G. TRANSACTION MATRIX

APPLICATION AREA

PREPARED BY DATE

INPUT TRANSACTION

ITEM DESCRIPTION	Activity Weather Log	New Meter Data Form	Meter Data Change Form	Occupant Check-in Sheet	Occupant Check-out Sheet	Occupant Change/Maint.	Norm Data Change/Maint.	Punched Reading Document	Punched Receipt	Meter Document Request	Fuel Content Change	Audit Trail Request	Dump Request	Cross-Reference Request	Rate Change Form				
TRANSACTION LIST APPEARANCE																			
MRD Transaction Register (Report #MB1P6-A)								X											
Customer Receipts Register (Report #MB1P1-B)									X										
Account File Transaction List (Report #MB1P1-A)	X	X	X	X	X	X	X		X		X				X				
Audit Trail Report (Report #MB1P9-A)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
EDIT LIST APPEARANCE																			
Meter Document Edit List (Report #MB1P6-B)								X											
Meter Device Maintenance Edit (Report #MB1P1-C)		X	X																
Occupant Data Error List (Report #MB1P1-D)				X	X	X			X										
Norm Data Error List (Report #MB1P1-E)	X						X				X				X				
Untitled Error List (No Report #)										X		X	X	X					

H. <u>Explanation of Keypunch Terms</u>.

<u>AS SHOWN</u>. Punch characters represented on the document without translation or adjustment in field.

<u>AS SHOWN, LEFT ZERO</u>. Punch characters represented on the document without translation. Right justify data, in the field filling uncoded high-order positions with zeros.

<u>AS SHOWN, SPACE RIGHT</u>. Punch characters represented without translation. Left justify data in the field, leaving uncoded low-order positions blank.

<u>LEFT ZERO</u>. Right justify data in the field, filling uncoded high-order positions with zeros.

<u>RIGHT JUSTIFY</u>. Shift characters so that right-most character coded is in the right-most position in the field.

I.

BASIC BUILDING SURVEY DATA

stallation:__________________ 2. Activity Identifier Code: [ ][ ][ ][ ][ ][ ] (3–8)

3. Building Number: [ ][ ][ ][ ][ ][ ] (9–14) 4. Account Number: [ ][ ][ ][ ][ ][ ] (15–20)

5. Address: [ ] (21–40)

6. Number of Occupants: [ ][ ] (41–42) 7. Number of Bedrooms: [ ] (43)

8. Floor Area: [ ][ ][ ][ ] (44–47) 9. Building Volume: [ ][ ][ ][ ][ ] (48–52)

10. Window Area: [ ][ ][ ] (53–55)

11. Domestic Water Heater Fuel: (G = Gas, E = Elect, O = Oil, S = Steam, H = Hot Water) [ ] (56)

12. Cooking Fuel: (G = Gas, E = Elect) [ ] (57)

13. Pilot Lights: (indicate number of Pilots, 0-9)

a. Domestic Water Heater: [ ] (58) b. Range: [ ] (59)

c. Clothes Dryer: [ ] (60) d. Furnace: [ ] (61)

e. Air Conditioner: [ ] (62)

1′ ting System:

a. Fuel: (G = Gas, E = Elect, O = Oil, S = Steam, H = Hot Water) [ ] (63)

b. Type: Forced Air_____, Baseboard_____, Convector_____, Radiator_____

c. Output Capacity:______________________Btu/hr

d. Age:________Years

15. Cooling System:

a. Fuel: (G = Gas, E = Elect, O = Oil, S = Steam, H = Hot Water, C = Chilled Water) [ ] (64)

b. Type: Central Air_____, Window Units_____, Evaporative Cooling_____

c. Number of Units:________

d. Capacity and Age of Each Unit:

1)______________________Btu/hr ________Years

2)______________________ ________

3)______________________ ________

I.

Activity Identifier Code [ ][ ][ ][ ][ ][ ]

Building Number [ ][ ][ ][ ][ ][ ]

Account Number [ ][ ][ ][ ][ ][ ]

. List all common energy consuming devices outside the dwelling which are to be billed to the occupant and estimate their daily consumption.

a. Electrical (KWH)

Total [ ][ ][ ]

b. Gas (Btu's)

Total [ ][ ][ ][ ][ ][ ]

c. Oil (Btu's)

Total [ ][ ][ ][ ][ ][ ]

d. Steam (Btu's)

Total [ ][ ][ ][ ][ ][ ]

e. Hot Water (Btu's)

Total [ ][ ][ ][ ][ ][ ]

f. Chilled Water (Btu's)

Total [ ][ ][ ][ ][ ][ ]

al Building Description:

a. Construction Type:
(C = Precast Concrete, F = Frame, B = Brick/Block, M = Masonry,
O = Brick/Frame, S = Steel [ ]

b. Year structure was built: [ ][ ]

c. Has building been weatherstripped and caulked: (Y = Yes, N = No) [ ]

d. Does structure have storm windows/doors: (Y = Yes, N = No) [ ]

e. Type of Dwelling:
(S = Single Family, D = Duplex, T = Townhouse, O = Other [Specify]) [ ]

f. If more than two family, is unit:
(E = End Unit, C = Center Unit) [ ]

g. Is unit (T = top floor, M = middle floor,
L = lowest floor) [ ]

h. Number of stories [ ]

i. Indicate basement, crawl space, or slab:
(B = Basement, C = Crawl Space, S = Slab) [ ]

.s there an attic: (Y = Yes, N = No) [ ]

SUPPLEMENTAL BUILDING INFORMATION*

Activity Identifier Code

2. Building Number
3. Account Number
4. U Factor and Infiltration Constant (A)
5. Internal Gain Constant (B1)
6. Building Mass Factor (B2)
7. Set Point Temperature Factor (B3)
8. Heating System Efficiency (EFFFUR)
9. Hot Water Heater Efficiency (EFFDWH)
10. Cooling System Coefficient (COP)
11. COP Adjustment Factor (C1)

Infiltration Load Factor (C2)

13. Solar Load Factor (C3)
14. Internal Load Level (IG)
15. Air Change Rate (ACR)
16. Heating Fan Consumption Factor (FH)
17. Cooling Fan Consumption Factor (FC)

*REVISED PAGE—22 MAY 78

DRAFT

Analyses of Family Housing Norms

CERL-EH
December 1979

1 INTRODUCTION

The purpose of this work was to analyze the adequacy of the one-year test norms as described in Chapter 2, section I and to determine areas where the norm could be refined to produce an accurate and defendable system that could be used to charge military occupants for excessive energy use. CERL checked the consistency of the norm against actual consumption for various sizes, construction types, occupancies, and locations of military family housing units.

A large amount of data is available for each family housing unit included in the test metering program. Even so, however, analyses of the data to determine the exact variables causing variations between actual data and norm projections is difficult. Numerous variables are involved in the heating, cooling, and hot water requirements of a family housing unit as in any other structure. Among the most important are: Weather conditions, thermal adequacy of the units, including insulation levels and infiltration rates, size, construction materials, indoor set points, and occupant life style. The field survey of the Family Housing units in the test metering program included a determination of the insulation levels and infiltration rates and numerous other building parameters, but occupant life style could not be defined as a survey item and only the number of occupants was included in the survey.

Approach

During the actual running of each military family housing billing cycle, historical data tapes were produced by NAVFAC. The data included the survey information for each family housing unit, the weather conditions, the actual consumption and the calculated norm for each billing cycle. The NAVFAC tapes also included a monthly proration of the actual and norm to produce monthly reports. It is the proration data that were used in the analysis. The proration of actual and norm consumption are not exact for complete comparison with weather data purposes; however, it provides a good basis for comparing actual consumption and norms over a continuous period of time and will show accurate trends in consumption of the units.

CERL proceeded to recode the NAVFAC data so it could be handled easily by the Statistical Package for the Social Sciences (SPSS), an integrated system of computer programs designed for the analyses of scientific data. This program allows the user to select subgroups of data for extensive analyses and compare between the subgroups. CERL selected units for analyses by analyzing the data to determine the mean of the actual consumption and norm for several groups of family housing units that were thermodynamically equivalent. These groups were then subjected to mean, variance and standard deviation computations to produce the curves and graphs presented herein.

Scope

This report includes actual and norm data comparisons (electrical and heating fuel) for 15 types of units at Port Hueneme, CA; Cannon AFB, NM; Fort Gordon, GA; Quantico, VA; and Little Rock AFB, AK.

Data Analyses

The first activity studied was Port Hueneme. The activity has a total of 515 military family housing units. The housing units are provided with electricity and natural gas. Natural gas is used for domestic hot water heating, cooking, and space heating. The units have no air conditioning. The initial group of units analyzed were 1262 sq. ft. (SF) single-story duplexes built in 1963. The three bedroom unit is an uninsulated stucco building on a concrete slab, and contains 210 SF of windows. The unit has a 72,000 Btu/hour gas-fired furnace, a gas hot water heater, a gas range, and no cooling system. Figure 1 shows the mean electrical consumption, mean norm, the maximum and minimum values of actual consumption in the sample, and the values associated with one standard deviation from the mean actual consumption. (The one standard deviation marks indicate that 68% of the actual data fall between these lines from the mean actual consumption). The low and high range indicate the minimum and maximum consumption in the sample. The data shows that for this three bedroom unit, the actual consumption averages 15% below the norm. This sample tends to indicate an overly generous electrical norm. The actual mean and the norm for this unit tend to track (as one goes up, the other goes up) very well, which indicates the

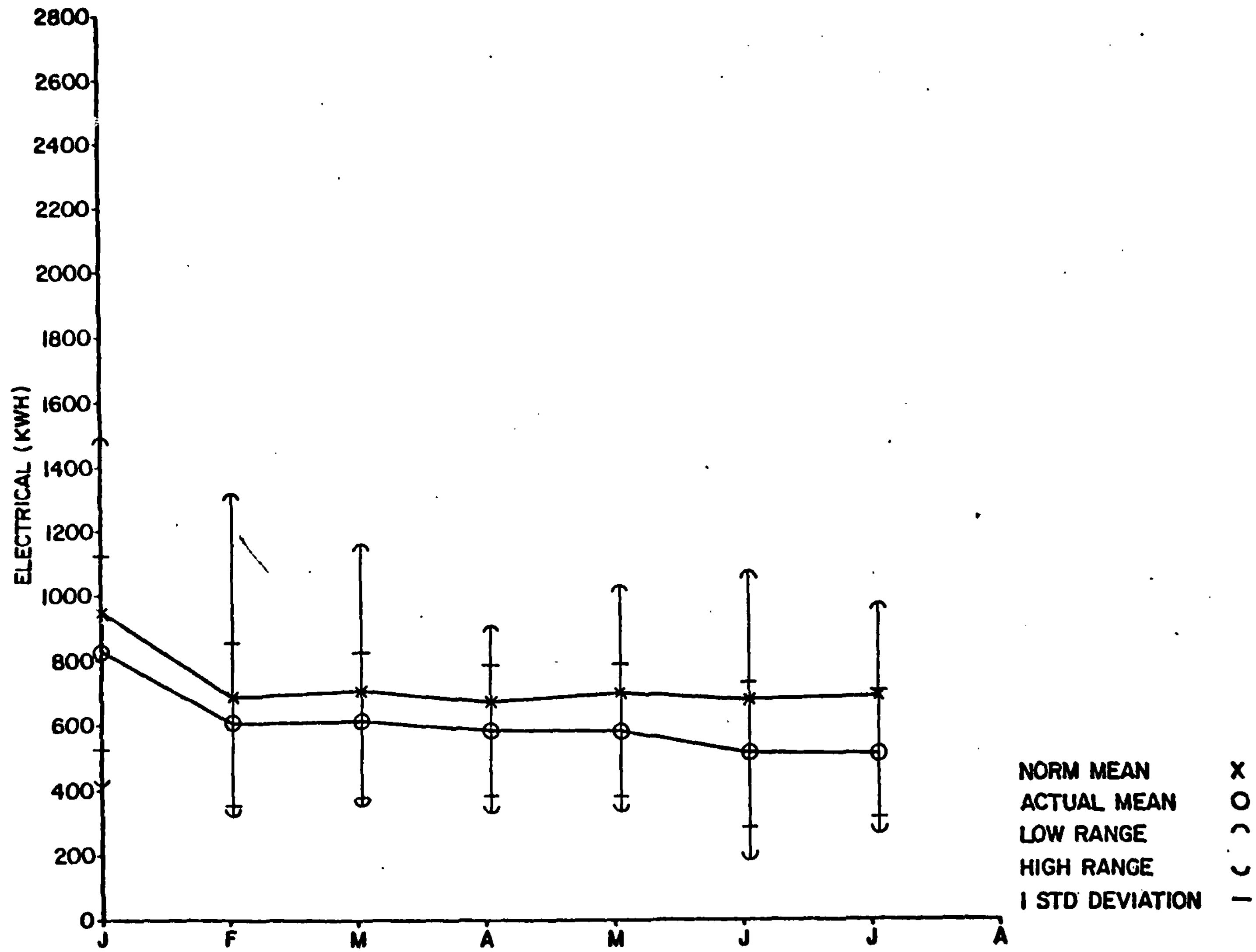

FIGURE 1 ELECTRICAL CONSUMPTION AND NORM VERSUS MONTHS (PORT HUENEME)

AD-A081 057 OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE (--ETC F/G 13/1
FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
MAR 80

UNCLASSIFIED NL

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A081057

monthly variation and electrical consumption provided by DOD for the norm prediction accurately reflects the diurnal electrical usage patterns. The actual and norm are closer during the months of January through May than in June and July. This could be due to less fan energy during the summer months.

Figure 2 shows the natural gas consumption against heating degree days for this same sample of housing units. Again, it is seen, the norm is higher than the mean actual consumption. The norm baseline consumption for pilot lights and cooling is shown on this figure to provide an indication of contributors to the norm. The dashed line shows the calculated norm, including the heating prediction as calculated by the heating algorithm. Weather parameters for Port Hueneme are shown on Table 1. The norm is then increased by an additional 4.7 CCF (hundred cubic feet) for each occupant of the units for domestic hot water heating. The dotted line shows what this consumption would be with four occupants in each building. The reason for the discrepancies between the norm and the actual consumption cannot be accounted for exactly. The norm and the actual consumption track each other quite well through the variable heating degree days indicating the heating algorithm contains the correct variables. We can surmise that any of the following problems could exist: Pilots and/or cooking norm consumption could be too high; heating algorithm is predicting too high due to incorrect thermal conductance/infiltration factor, furnace efficiency factor, improper regression coefficents from

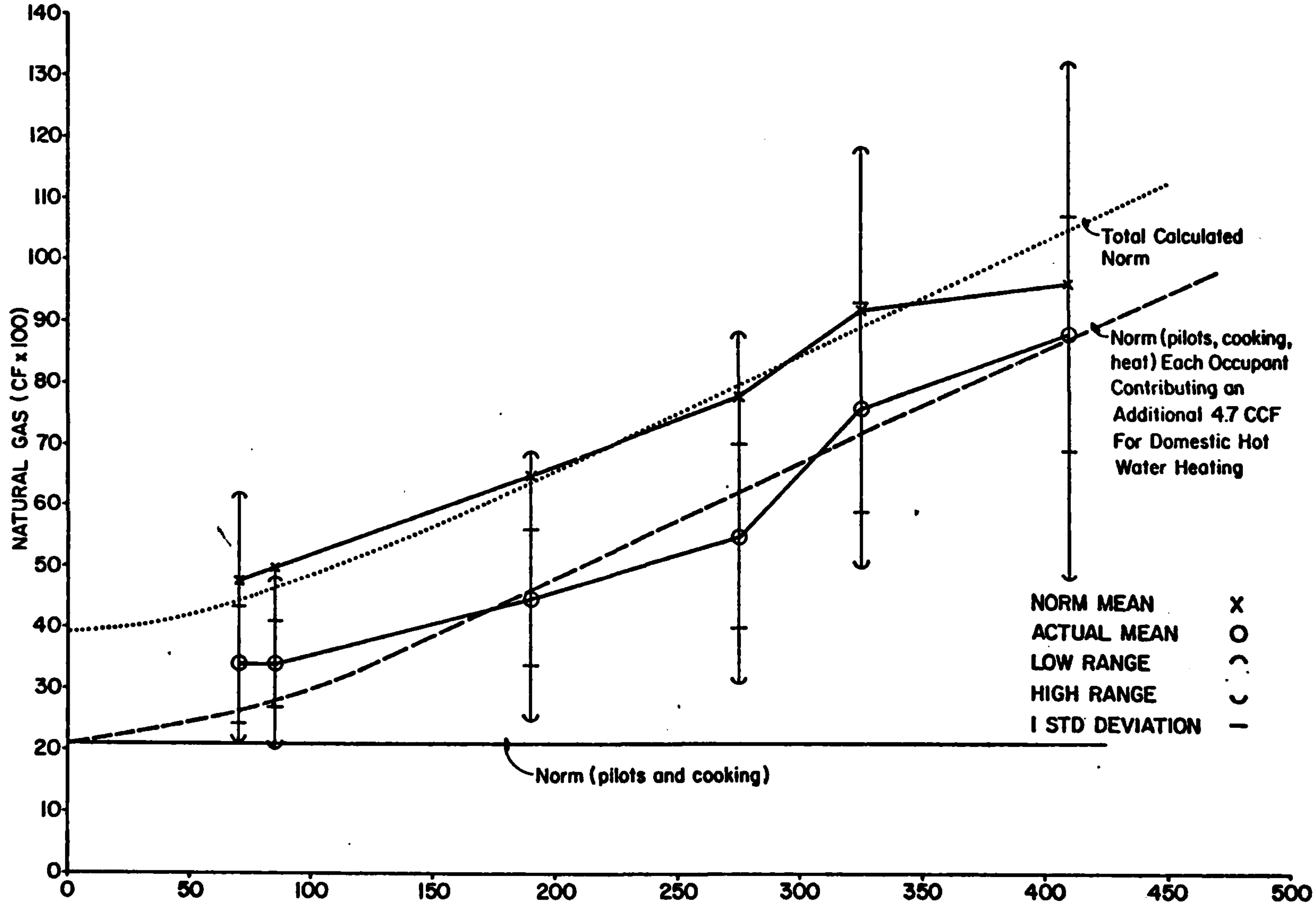

FIGURE 2 GAS CONSUMPTION AND NORMS VERSUS HDD (PORT HUENEME)

TABLE 1

WEATHER PARAMETERS

Activity: Port Hueneme

Month	Daily Heating Degree Days	Total Heating Degree Days	Hours Above 78°F	Temperature of Water Supply
JAN	13.77	427	--	65
FEB	14.67	411	--	65
MAR	10.58	328	7	65
APR	9.20	276	--	65
MAY	6.12	190	11	65
JUN	2.76	83	25	65
JUL	2.32	72	--	65
AUG	--	--	--	65

the BLAST program; or the hot water heating norm algorithm over-predicts actual requirements. A singular cause for the difference cannot be determined. Analysis of additional buildings at Port Hueneme may provide clarity for the trends indicated by this building group.

The next building group studied is a 415 SF duplex unit built in 1963. The three bedroom unit is an uninsulated stucco building on a concrete slab, has an attic, and contains 231 SF of windows. The building contains the same equipment as the previous building. Once again, the electric norm overpredicts by an average of 15% throughout the duration of the period as shown on Figure 3. The norm is closer to the actual during the early months of the year and the variance tends to get larger in the summer months as in the first building group.

Figure 4 shows the gas consumption vs. heating degree days for this group of buildings. These curves are very similar to those for the previous building where the norm is again higher than the actual consumption except during the higher heating degree day months where the norm mean and the actual mean are exactly the same. The excellent tracking of these two curves would also indicate that the norm is a better predictor during the higher heating degree day months than during the interim spring and fall seasons. It is noted that extremely wide fluctuations in actual consumption are evident in this sample of units as the minimum consumption and the maximum consumption are roughly 40 CCF

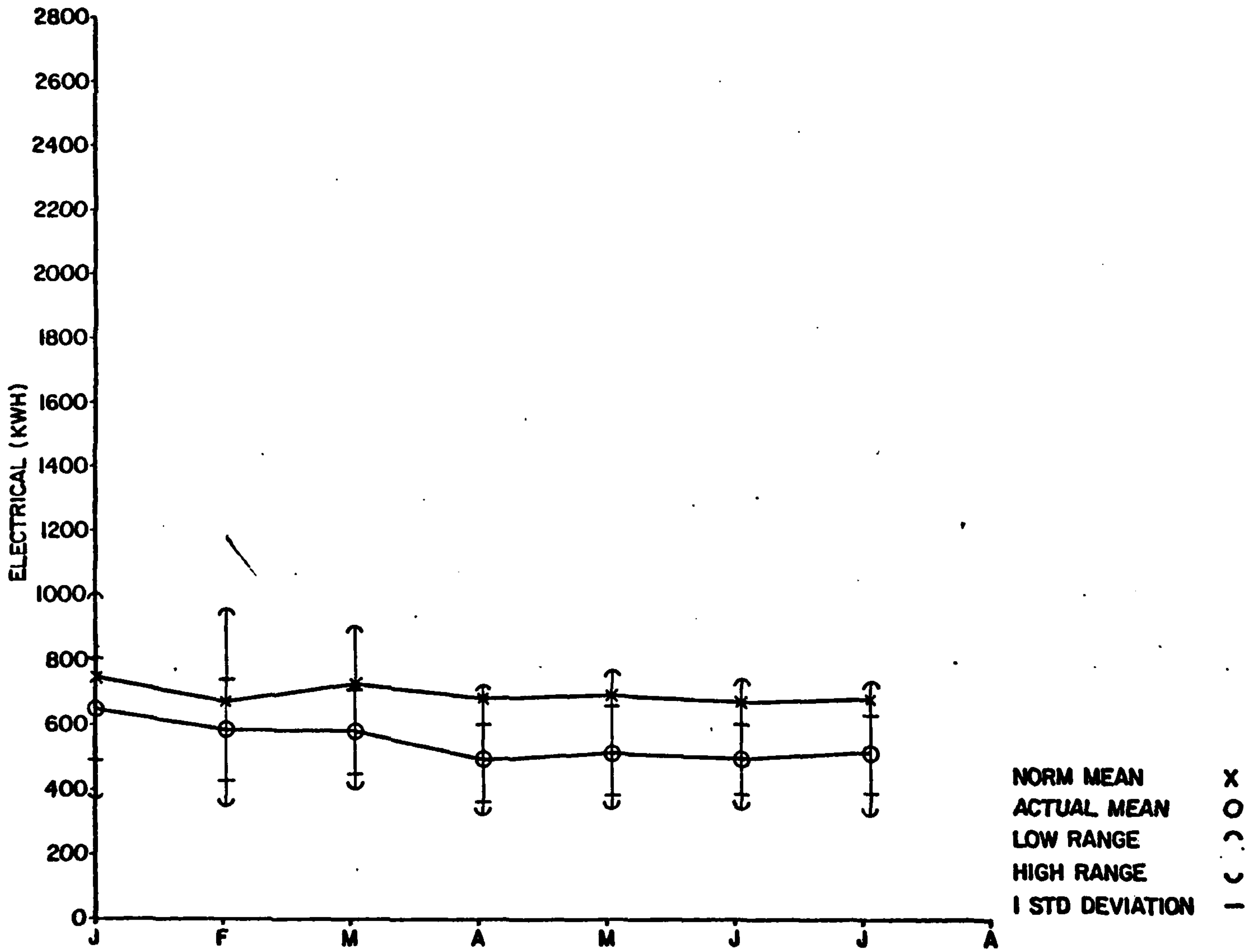

FIGURE 3 ELECTRICAL CONSUMPTION AND NORM VERSUS MONTHS (PORT HUENEME)

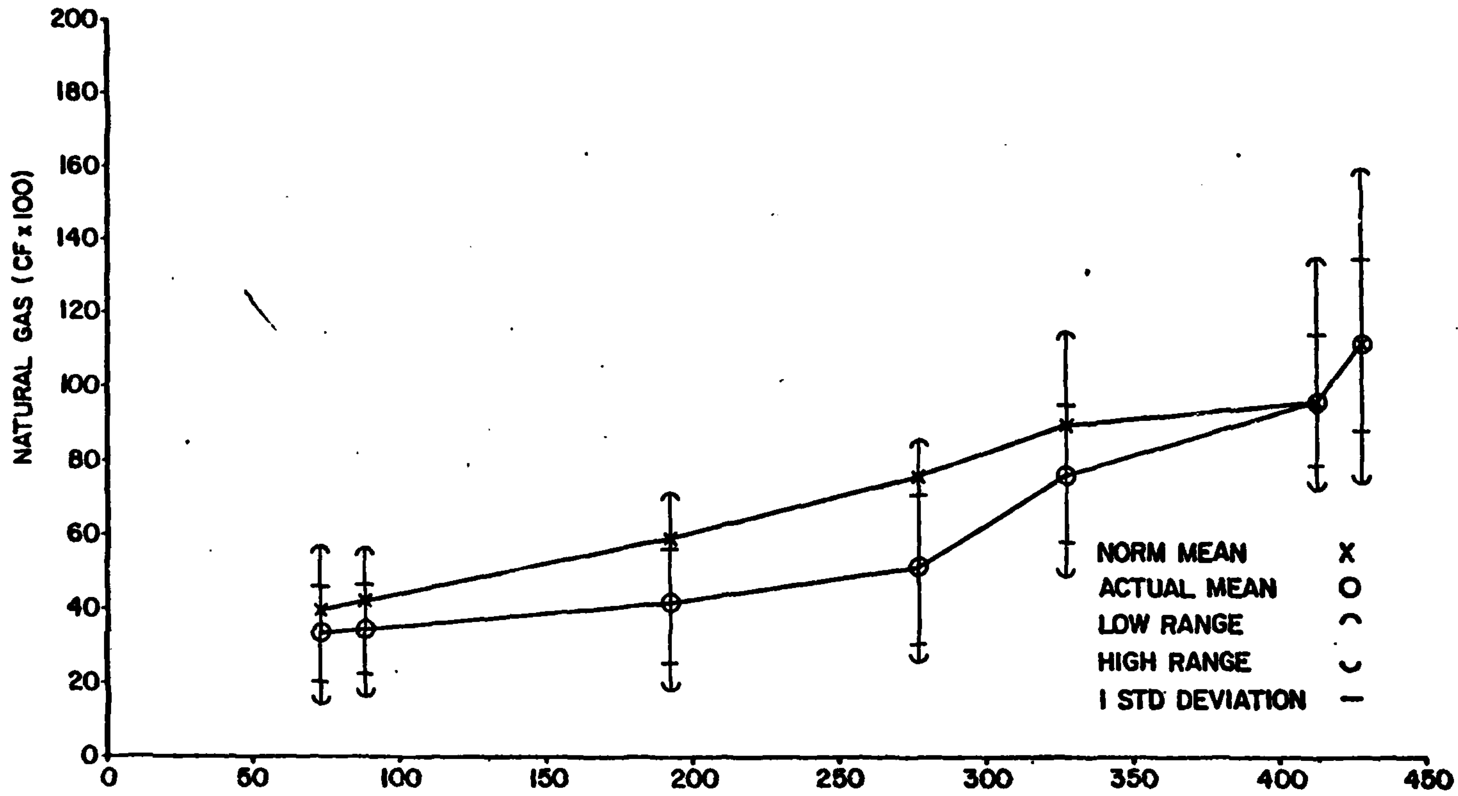

FIGURE 4 GAS CONSUMPTION AND NORMS VERSUS HDD (PORT HUENEME)

on either side of the actual mean. This wide discrepancy could be due to a number of factors such as different indoor thermostat setpoints, maintenance on furnaces which would cause efficiency to vary greatly from unit to unit, or widely varying lifestyles. Although the construction of these buildings are exactly the same, some minor variations in orientation, window facing directions, and infiltration rates could also cause some variance in minimum and maximum consumption of gas for the units.

A third building studied at Port Hueneme is a 1426 SF single family, four bedroom, one-story dwelling. The uninsulated stucco building has a 72,000 Btu/hour gas furnace, a gas hot water heater, and gas range. The building has 229 SF of windows. Figure 5 shows the electrical consumption and norms for this building. In this building type, the actual mean consumption is higher than the norm for January through March and nearly equal in the remaining months. As was indicated on the previous electrical curves, it appears the fan consumption factor for heating may be lower than it should be based on the actual usage indicated in high heating system use months. It can again be seen the variance between the low user and high user is quite large, spanning about 800 KWH. The main difference between this building sample and those shown on Figures 1 and 3, is that it is a single family 4 bedroom unit instead of a 3 bedroom duplex unit. The average monthly consumption for the single family units is 100 KWH/month higher than for the duplexes.

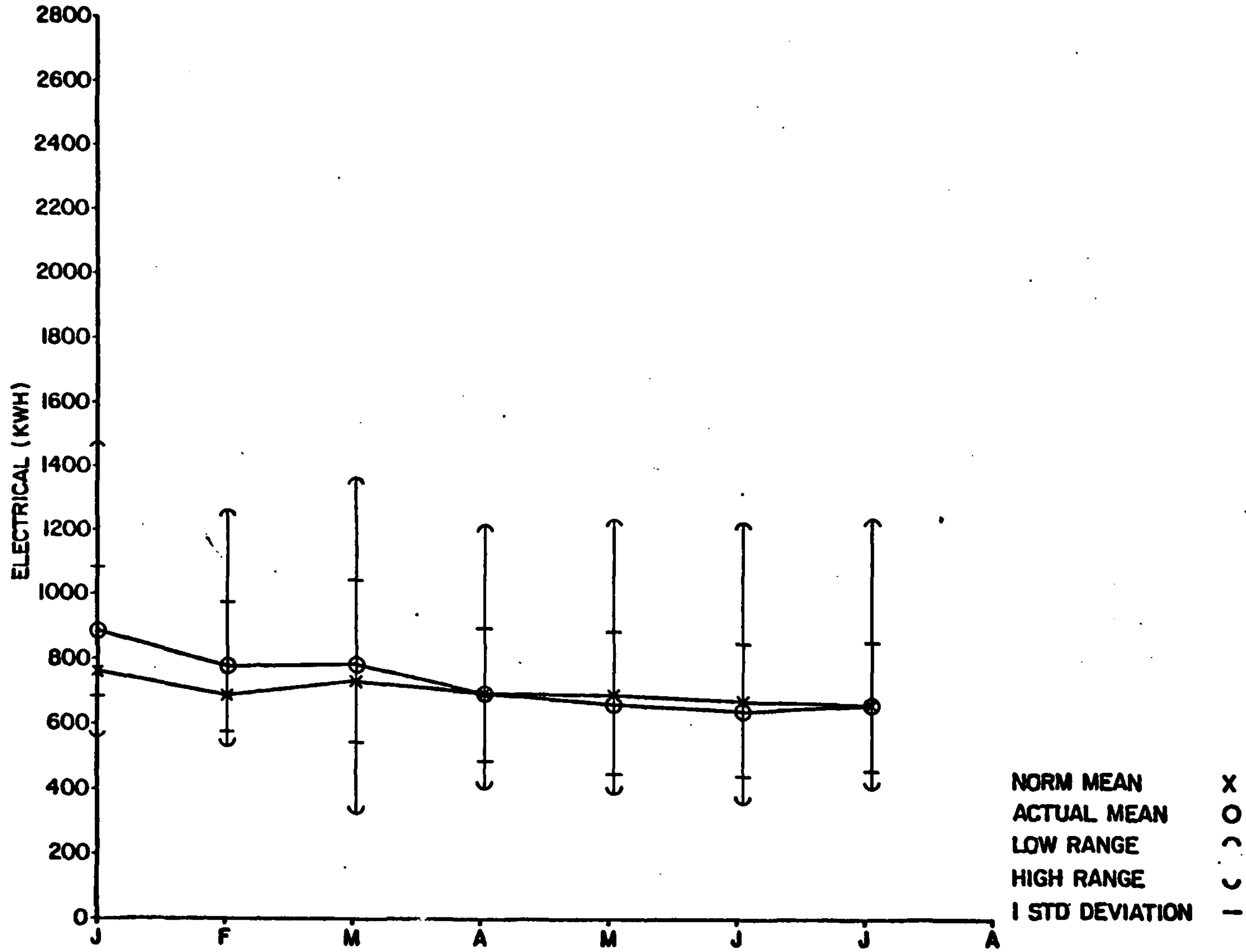

FIGURE 5 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (PORT HUENEME)

Figure 6 shows the natural gas consumption and norm plotted against heating degree days. The same trends for this building sample are evident from the figure as in the building samples shown in Figure 2 and 4. The norm averages approximately 10 CCF higher than the mean of the actual consumption for this sample. Again, no singular reason for this difference can be determined.

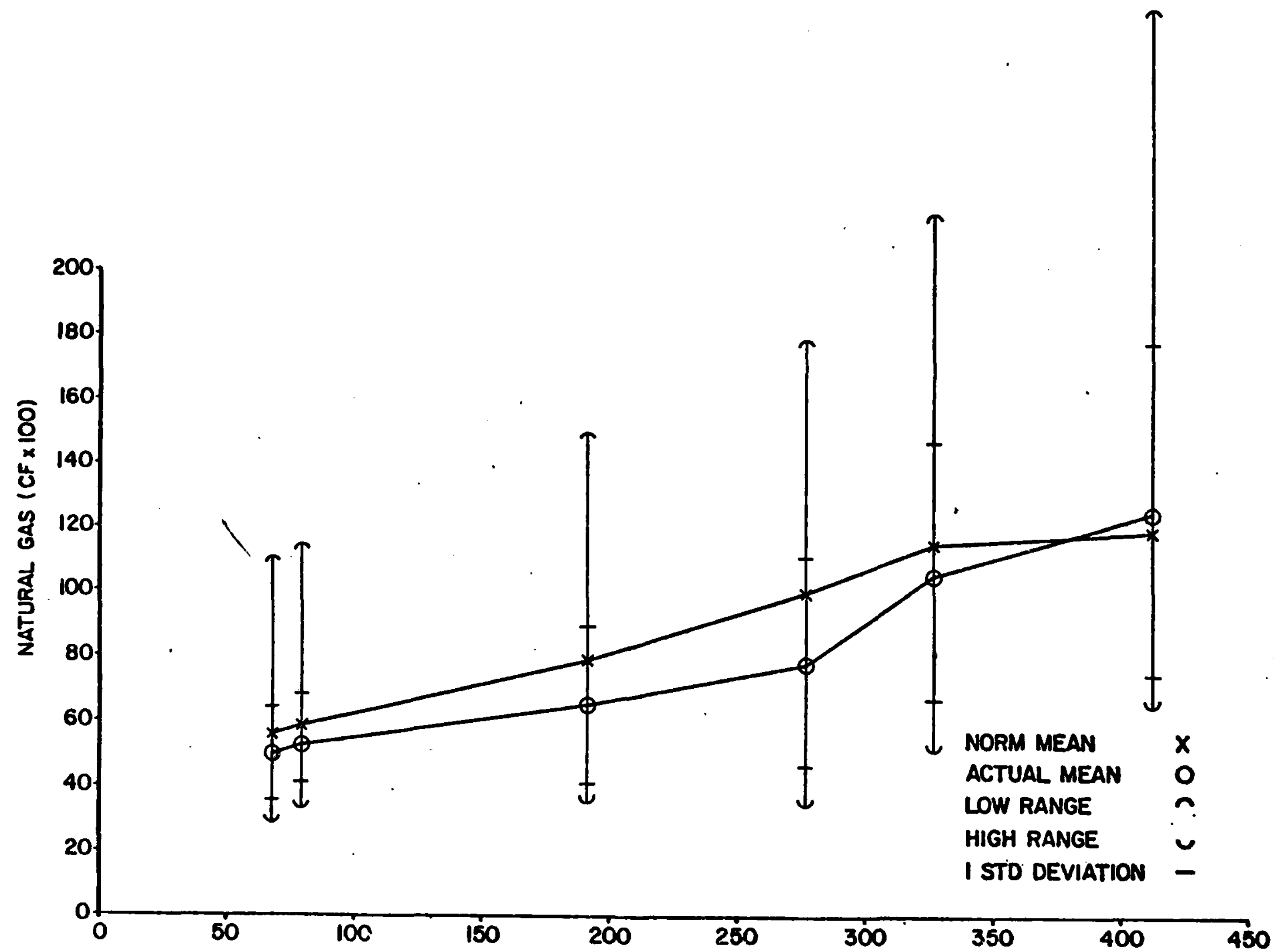

FIGURE 6 NATURAL GAS CONSUMPTION AND NORMS VERSUS HDD (PORT HUENEME)

The differences noted at Port Hueneme in the electrical consumption between duplexes and single family units cannot be accurately determined. The four bedroom units shown on Figure 5 use 100 KWH per month more than the duplex units which are three bedrooms units. The number of occupants in each sample group is equivalent. The gas consumption for all three units track quite well indicating the heating algorithm correctly predicts consumption based on heating degree days. Adjustments to heating system efficiency or corrections to the infiltration/conduction factor for the buildings could bring the actual mean and the norm mean very close together. The large differences between the minimum and maximum consumption in these thermodynamically equivalent units, however, support a determination that wide variances in actual consumption are primarily due to occupant life style differences.

Cannon Air Force Base

Cannon Air Force Base was the next activity chosen for analyses. Cannon Air Force Base has a total of 1,012 family housing accounts. The units are heated by natural gas, have gas hot water heaters, and gas ranges. The units are equipped with electrical central air conditioners. The first building sample studied is a 993 SF, three bedroom town house (center unit) with 144 SF of windows and an infiltration/conduction factor of 10,521. The units are brick and frame structures. Weather parameters for Cannon Air Force Base for the monitoring period are shown on table 2. Figure 7 shows the electrical consumption and norms vs. months for these units. It can be seen that the norm is consistently higher than the actual consumption. However, it can also be seen that as the norm goes up, the actual consumption

TABLE 2

WEATHER PARAMETERS

Activity: Cannon AFB

Month	Daily Heating Degree Days	Total Heating Degree Days	Hours Above 78°F	Temperature of Water Supply
JAN	34.96	1084	0	68
FEB	24.32	681	3	68
MAR	17.38	539	2	68
APR	8.80	264	28	68
MAY	3.54	110	87	68
JUN	1.13	34	191	68
JUL	--	--	318	68
AUG	--	--	242	68

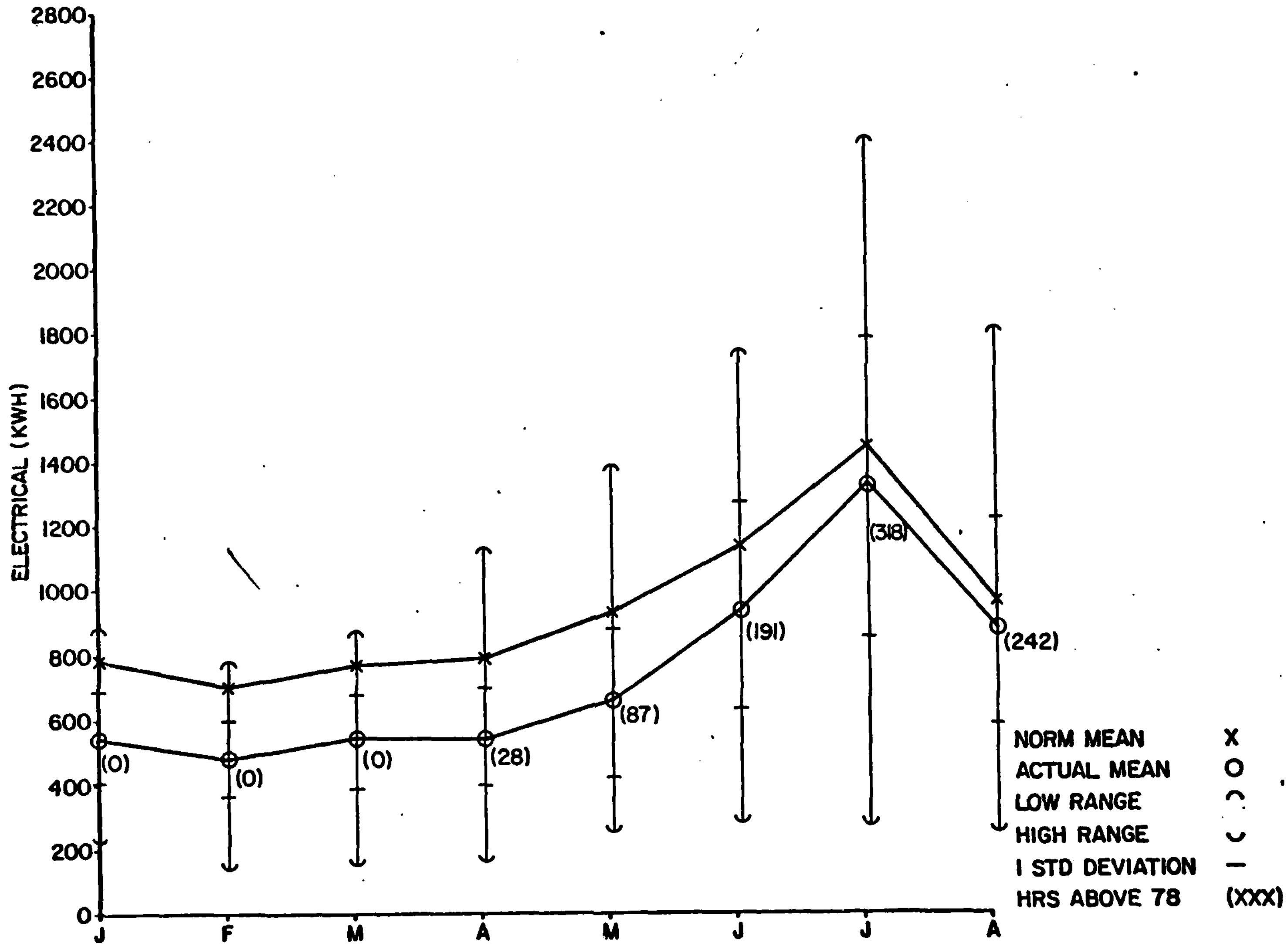

FIGURE 7 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (CANNON AFB)

also increases. Beginning in May, the increases due to electrical air conditioning are very evident. The norm and actual difference becomes less in the summer months indicating that the cooling algorithm underpredicts the actual cooling load or the occupants are cooling their houses to less than 78^{o} F. Again, it can be seen that the baseline electrical norm tends to be high for this type of unit. The obvious drop in the month of August in electrical requirements is caused by the proration of actual and mean data over a monthly period instead of the actual billings period, indicating only a part of the August data was included. The numbers in parentheses on Figure 7 show the number of hours the outdoor temperature exceeded 78^{o}. This weather parameter is used in the norm algorithm to determine cooling load requirements.

Figure 8 shows the gas consumption and norm vs. heating degree days for this sample of buildings. It is seen that for very low heating degree days the norm is only slightly higher than actual consumption and as the number of heating degree days increase, the actual consumption becomes higher than the predicted norm. This variation could be due to norm use of a high furnace efficiency, incorrect determination of the infiltration/conduction factor, or thermostat set points higher than 68^{o} F within the family housing units. The fact that the norm mean and actual mean track accurately indicates that the norm heating algorithm accurately predicts the trends in gas energy consumption.

Figure 9 shows a frequency distribution of the gas usage for this unit in the month of January. This figure indicates the extreme variances in usage between the minimum users and the maximum users. This sample includes 46 thermodynamically equivalent family housing units. Figure 10 and 11 show

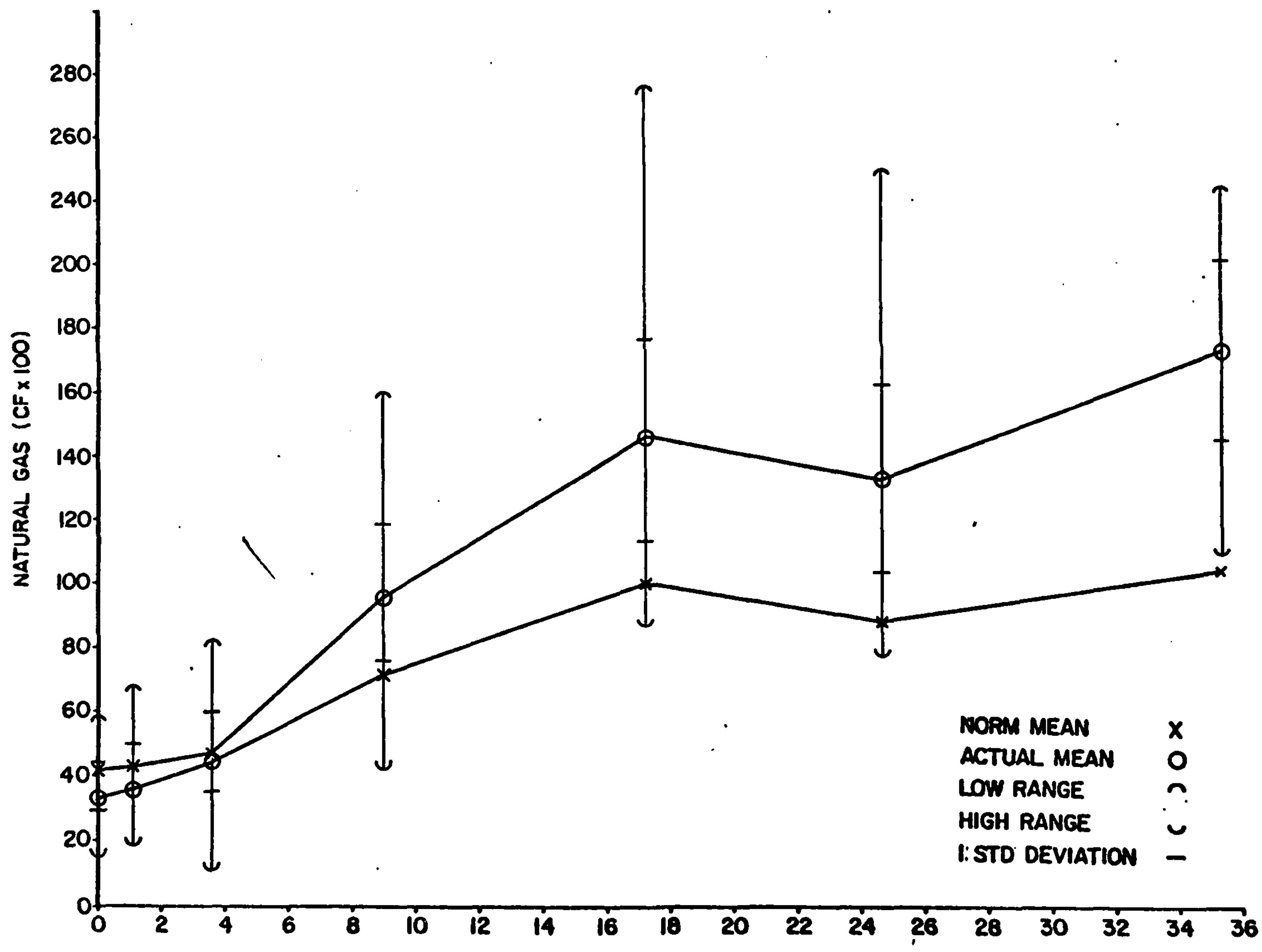

FIGURE 8 GAS CONSUMPTION AND NORM VERSUS DAILY HDD (CANNON AFB)

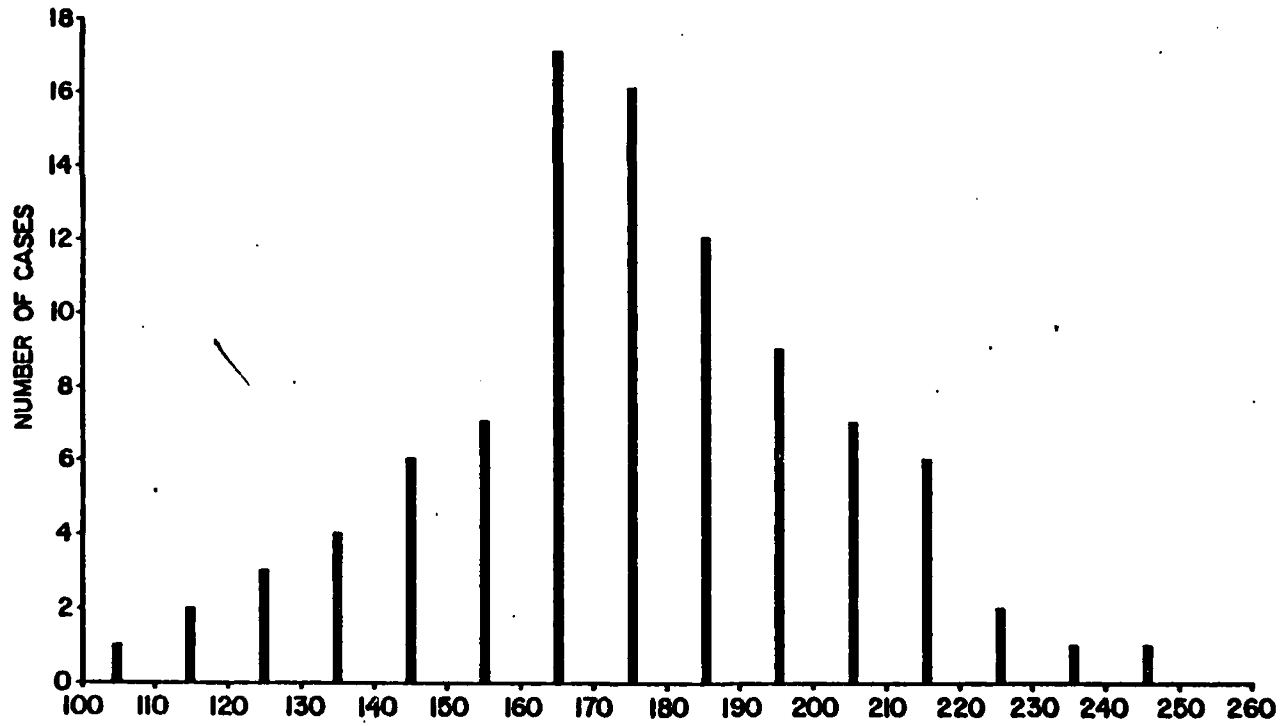

FIGURE 9 FREQUENCY DISTRIBUTION OF GAS USAGE - JANUARY

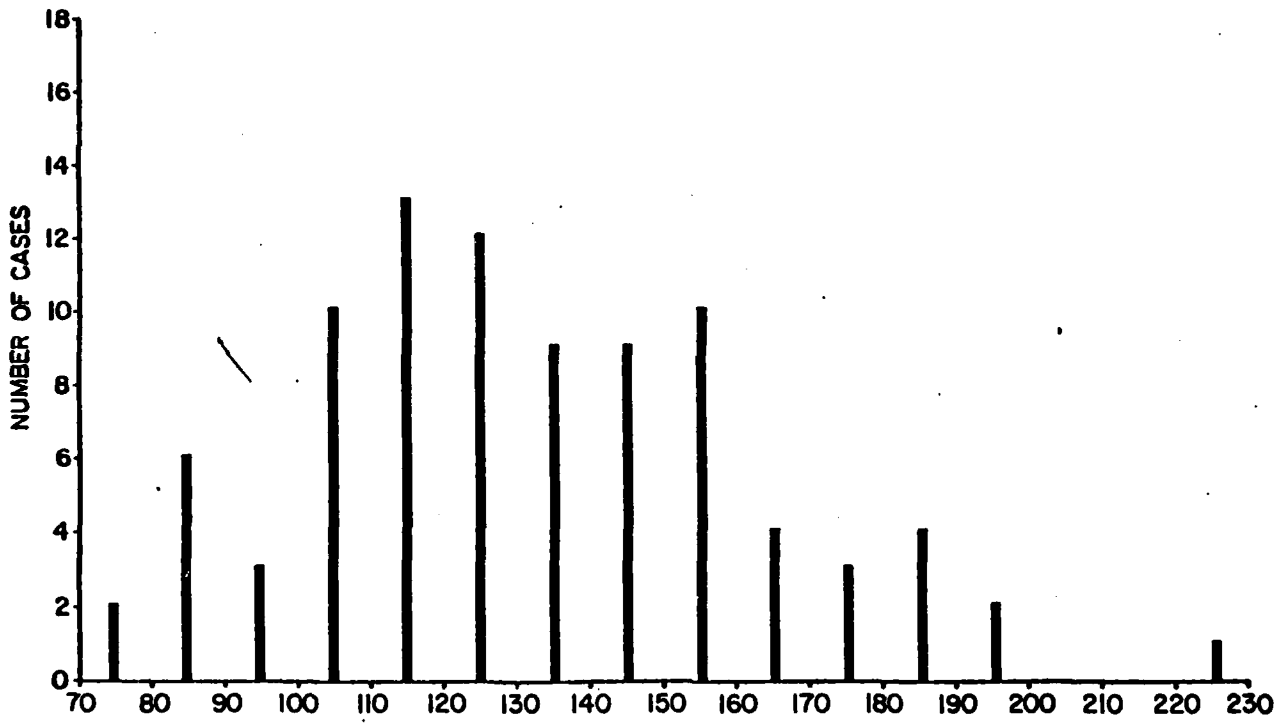

FIGURE 10 FREQUENCY DISTRIBUTION OF GAS USAGE - FEBRUARY

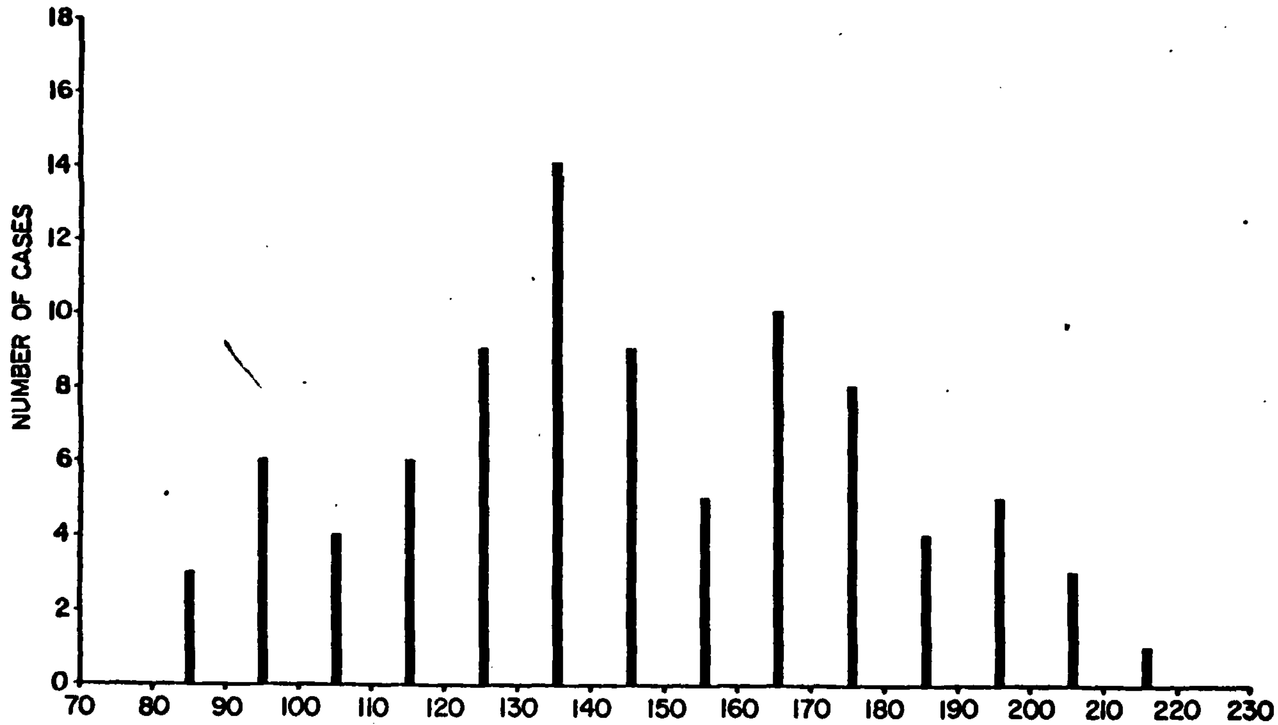

FIGURE 11 FREQUENCY DISTRIBUTION OF GAS USAGE - MARCH

the frequency distribution of gas usage for the months of February and March respectively. Again, the large variance between the low user and the high user is evident. The larger group of cases within the mid-portion of the figures indicate the validity of the data as a statistical sample.

The next building studied at Cannon Air Force Base was identical to the previous unit except it is the end unit on the town house. This unit has a slightly higher infiltration/conduction factor of 10,989. Figure 12 shows the electrical consumption for this type of unit in comparison with the norms. Again, it can be seen the norm is higher than the mean of the actual consumption throughout the winter months and tends to become closer in the summer months supporting the previous speculation that the units are cooling to temperatures below 78^{o} or the cooling algorithm underpredicts the cooling requirements of the building. The trends indicated in this figure support the DOD diurnal variation in electrical consumption as the two curves (norm and actual) track nicely for the duration of the data.

Figure 13 shows the gas consumption and norms vs. the heating degree days for these units. The curve is very similar to that of the previous unit. However, a comparison between Figures 8 and 13 show that this town house end unit uses approximately 30 CCF more per month in the heating season than the center town house units. We would expect higher consumption due to a greater area of walls exposed to the exterior environment. The factors influencing the variance between norm and actual consumption are the same as for the center unit.

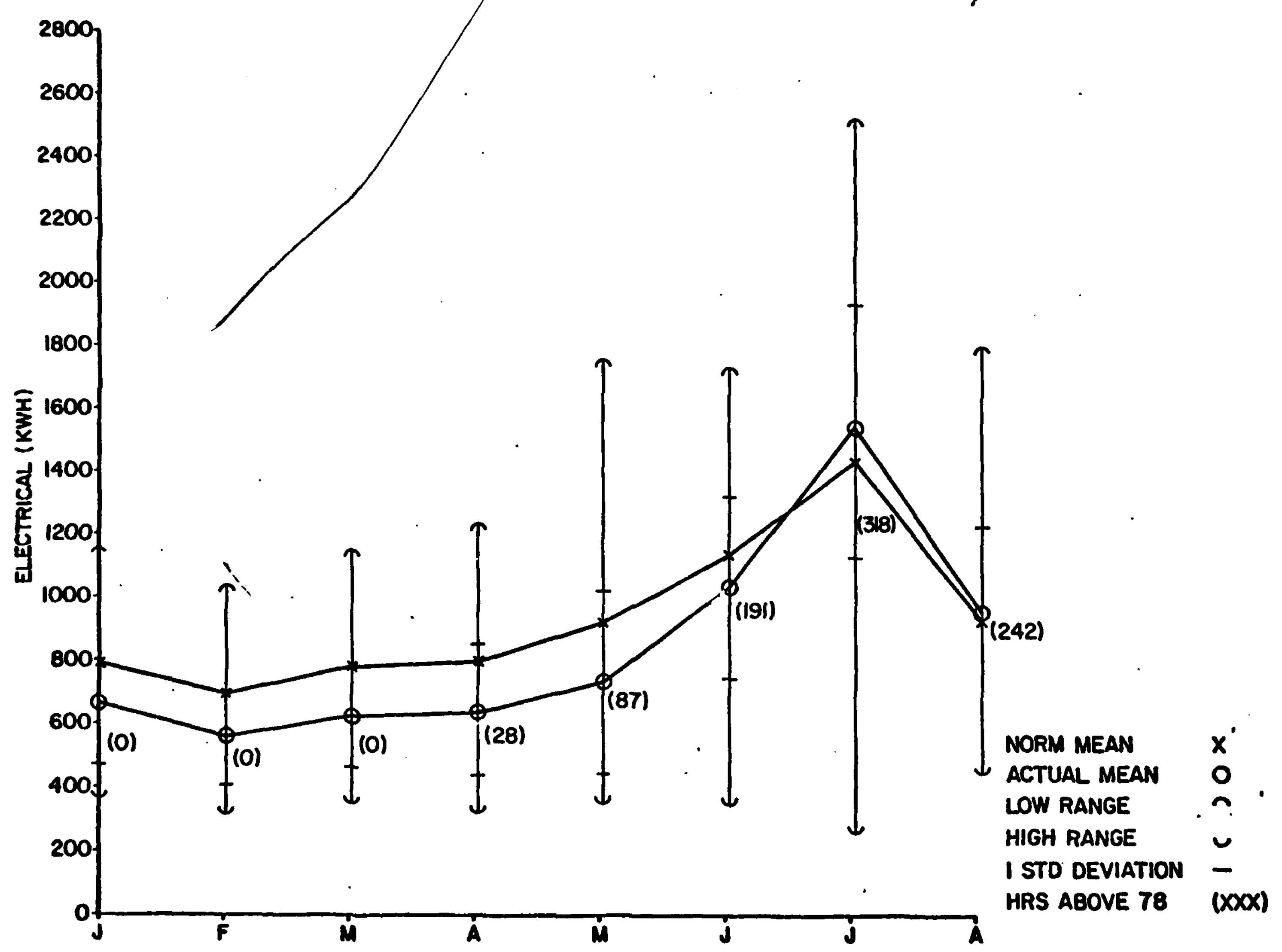

FIGURE 12 ELECTRICAL CONSUMPTION NORMS VERSUS MONTHS (CANNON AFB)

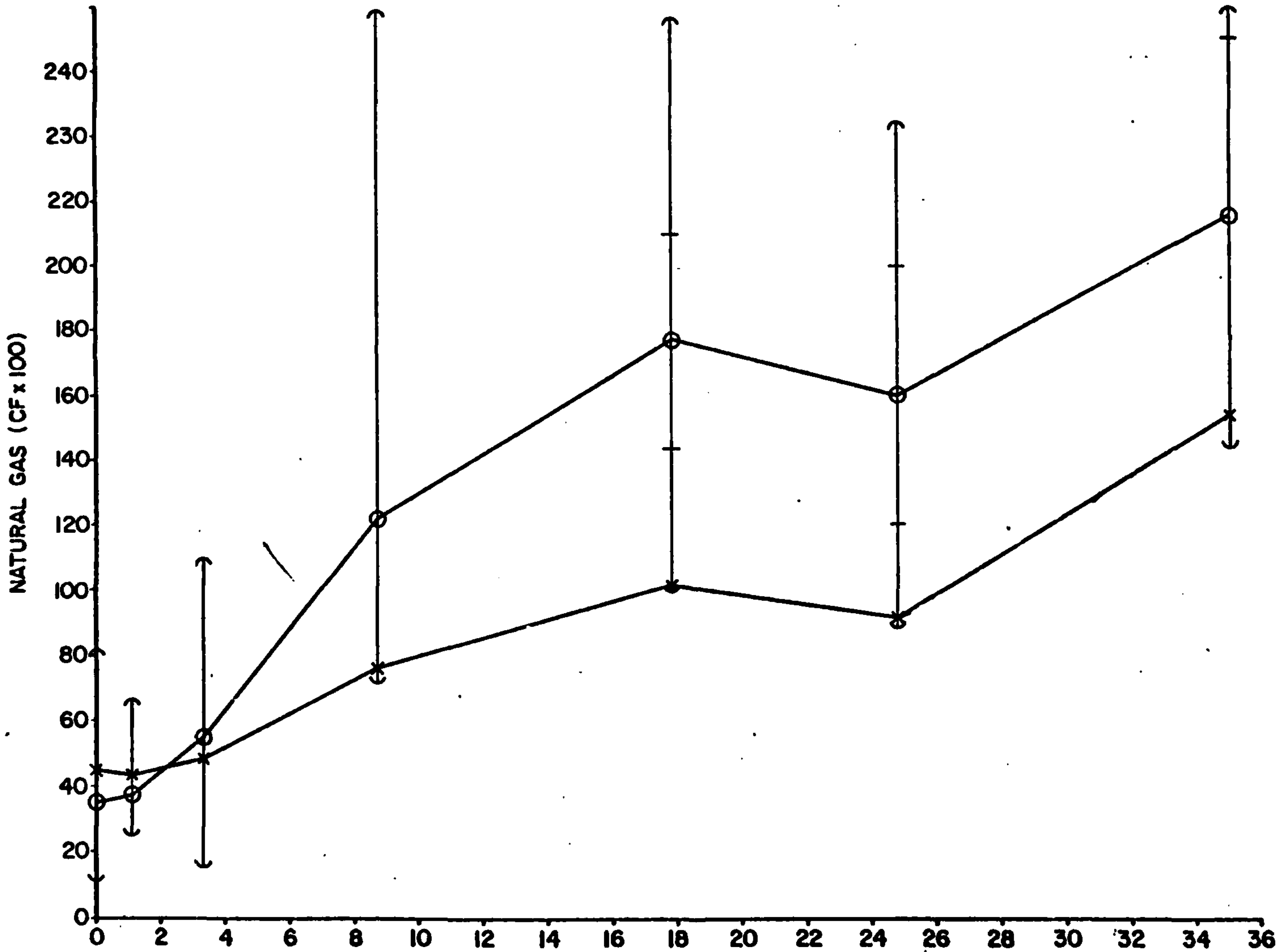

FIGURE 13 GAS CONSUMPTION AND NORMS VERSUS DAILY HDD (CANNON AFB)

Figure 14 shows electrical actual and norm data from a sample of 140 1560 SF single story duplexes. This unit also has a gas fired furnace, a gas range, and a gas hot water heater. The building was built in 1974 and has 193 SF of windows. As was evident from the Port Hueneme data, this four bedroom unit again uses roughly 100 KWH per month more than the three bedroom smaller units. The trends of the actual and the norm track each other well. Also evident from this curve as from the previous electrical consumption curves (Figures 10 and 12) is that the cooling algorithm tends to underpredict the cooling requirements in the building or the occupants are cooling their facilities to temperatures below 78^{o} F, causing higher usage. The norm always falls within one standard deviation from the actual consumption showing that a large percentage of the units use less energy than the norm allows.

Figure 15 shows the gas consumption and norms vs. daily heating days for this unit. The norm is consistently lower than the actual mean data. However, it can be seen by comparing Figure 15 with Figure 11 and 13 that these units with an infiltration/conduction factor of 15,621 (approximately 50% higher than the previous unit) uses 50% more heating energy as do the previous units. This shows that the infiltration/conduction factor is a valid method to describe the thermodynamic operation of a housing unit. The tracking of the norm and actual consumption shows that accuracy of the algorithm in predicting the heating requirements based on heating degree days. However, the difference between the norm and the actual is fairly large (30%) indicating some major problem may exist with the survey definition of this building type.

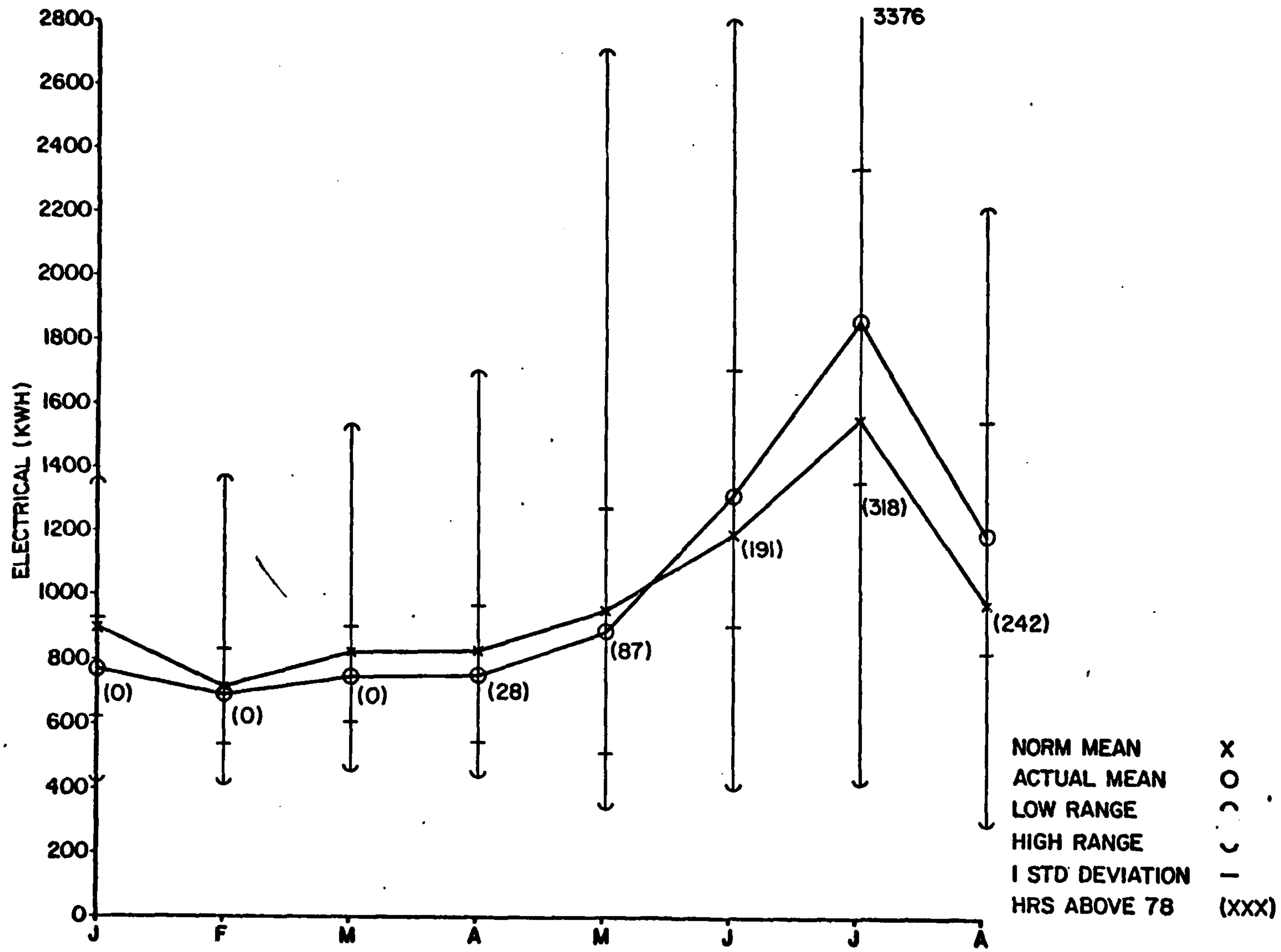

FIGURE 14 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (CANNON AFB)

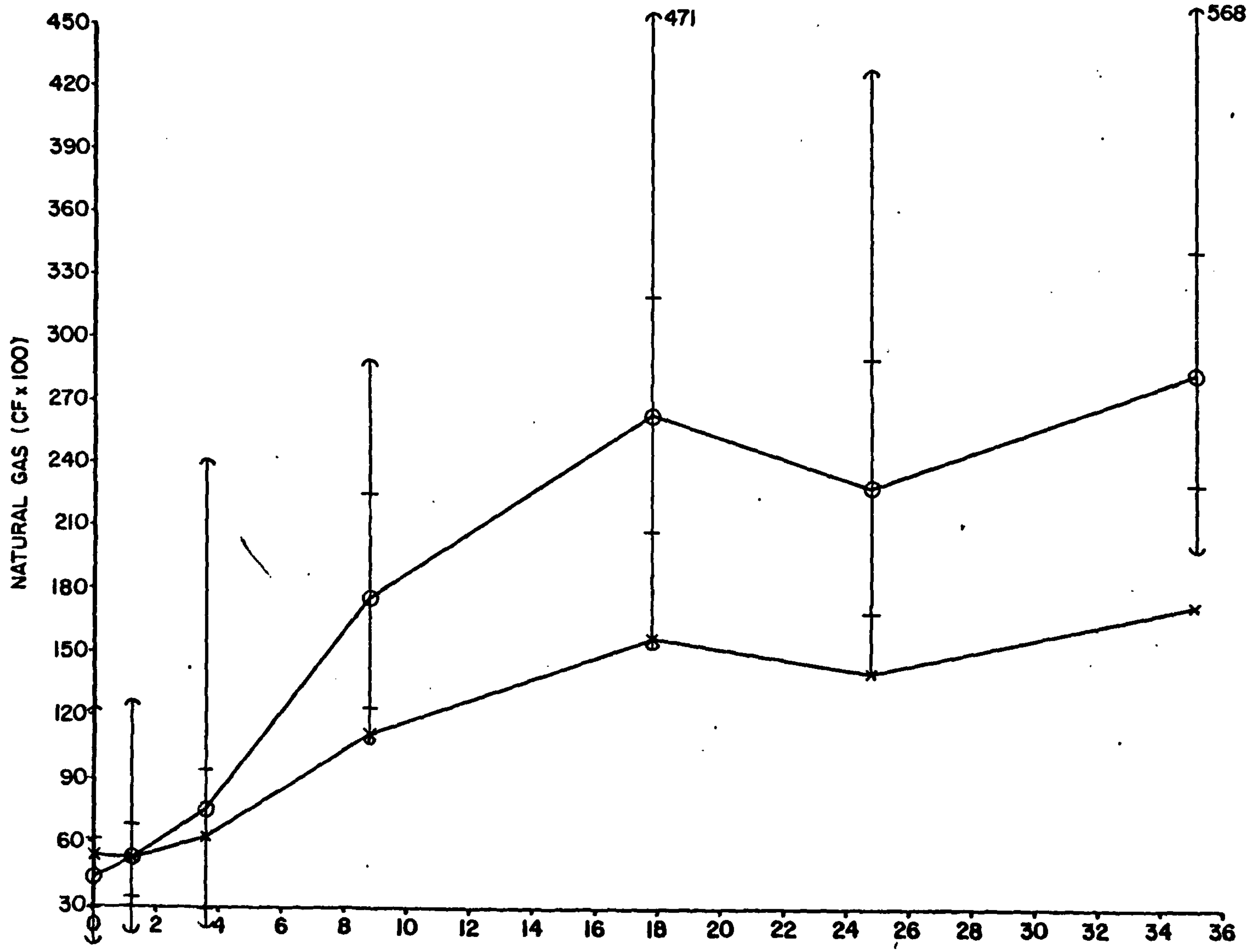

FIGURE 15 GAS CONSUMPTION AND NORMS VERSUS DAILY HDD (CANNON AFB)

Figure 16 shows the gas consumption and norms vs. daily heating degree days for the three units studied. Here a very good comparison between building types can be made. It is interesting to note that the heating consumption has the same general shape indicating that the heating degree day method of predicting heating consumption is an adequate and accurate method of predicting heating consumption.

To summarize the Cannon Air Force Base data, it has been shown that the electical norm has been consistently higher than the actual mean data for identical building groups which indicates that the DOD projected electrical energy consumption per unit, though containing proper diurnal adjustments, is higher than it should be. Data tends to indicate a more significant difference between 3 and 4 bedroom units than between 2 and 3 bedroom units as was used in calculation of the electrical norm. Data indicate the the cooling in the units is being accomplished at lower setpoints than 78^{0} or the algorithm utilized in the calculation of the norm needs to be adjusted such that it will more closely predict the cooling requirements of the buildings. The gas consumption at Cannon Air Force Base is consistently higher than the calculated norm. Refinement of the furnace efficiencies, sampling of indoor setpoints and a recheck of the calculated infiltration/conduction factor should be made to determine the cause of the variance.

<u>Quantico, VA</u>

The next installation studied was Quantico, VA. Weather parameters for Quantico are shown on table 3. Quantico has a total of 1,110 family housing units. Heating is done primarily by natural gas, however, propane

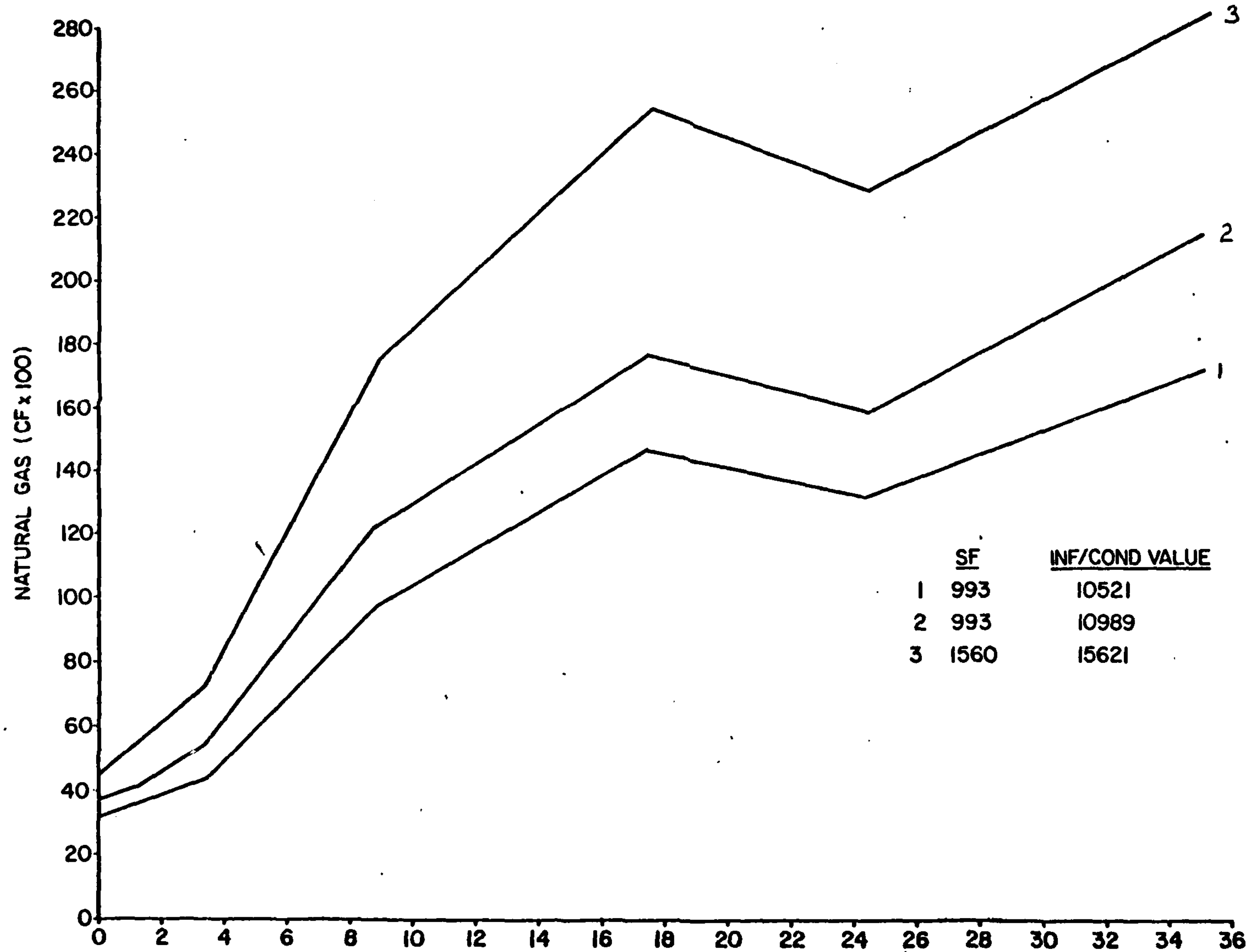

FIGURE 16 GAS CONSUMPTION AND NORMS VERSUS DAILY HDD (CANNON AFB)

TABLE 3

WEATHER PARAMETERS

Activity: Quantico

Month	Daily Heating Degree Days	Total Heating Degree Days	Hours Above 78°F	Temperature of Water Supply
JAN	25.35	786	--	50
FEB	31.03	869	--	43
MAR	12.96	402	4	49
APR	8.46	254	--	57
MAY	1.22	38	43	63
JUN	0.40	12	92	76
JUL	--	--	180	84
AUG	--	--	152	83

is also used in some of the units. The first building studied is a 808 SF two bedroom family housing unit built in 1952. The unit is a center town house, two story unit with natural gas used for heating, cooking and domestic hot water. The building has an infiltration/ conduction factor of 11,729. Figure 17 shows the electrical consumption and norms vs. months for this unit. It can be seen from this curve that the mean of actual consumption is again higher than the norm for these units. It shows the shape of the two curves are very similar; however, as cooling energy is required, the cooling norm calculates a requirement less than that of the actual consumption as was seen in the Cannon AFB data.

Figure 18 shows the gas consumption and norms vs. HDD for this unit. The actual consumption is higher for each month than the norm calculated consumption. Again, a very wide fluctuation in actual energy requirements are evident amongst thermodynamically equivalent family housing units. An example at the 400 heating degree days mark on the figure is shown where the minimum consumption is 9400 cubic feet and the maximum consumption is 24,200 cubic feet. As in previous figures, the norm tracks the actual consumption very nicely.

The next building group studied was a 693 SF two bedroom unit with 81 SF of window area. This building is a frame, duplex built in 1942. This building utilizes propane for heating, cooking, and domestic hot water heating and has an infiltration/conduction factor of 11,937. Figure 19 shows the electrical consumption for this unit. The actual electrical consumption is less than one half of the norm but does track the norm consumption nicely. Initial analyses of this data indicates the actual

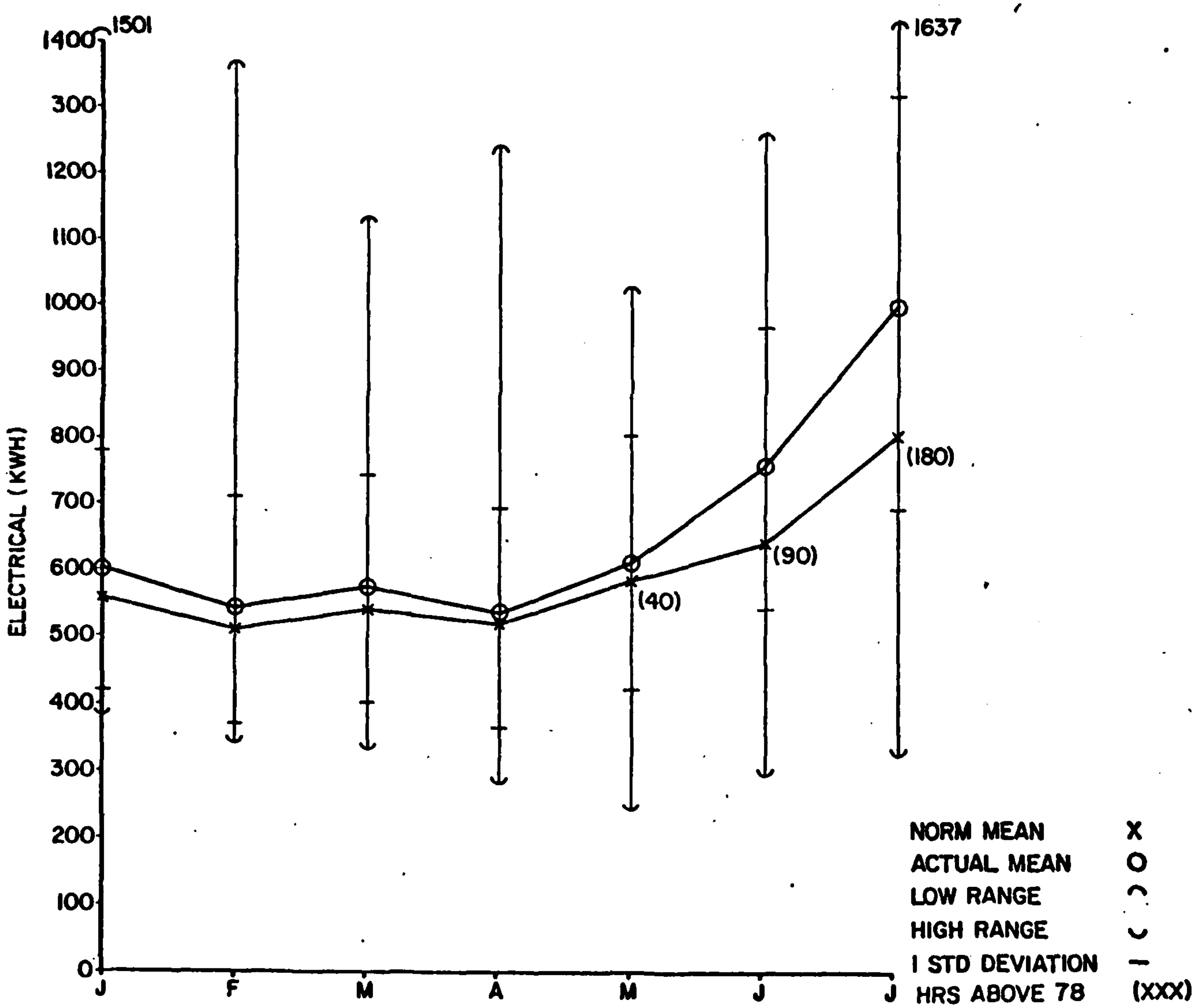

FIGURE 17 ELECTRIC CONSUMPTION AND NORMS VERSUS MONTHS (QUANTICO)

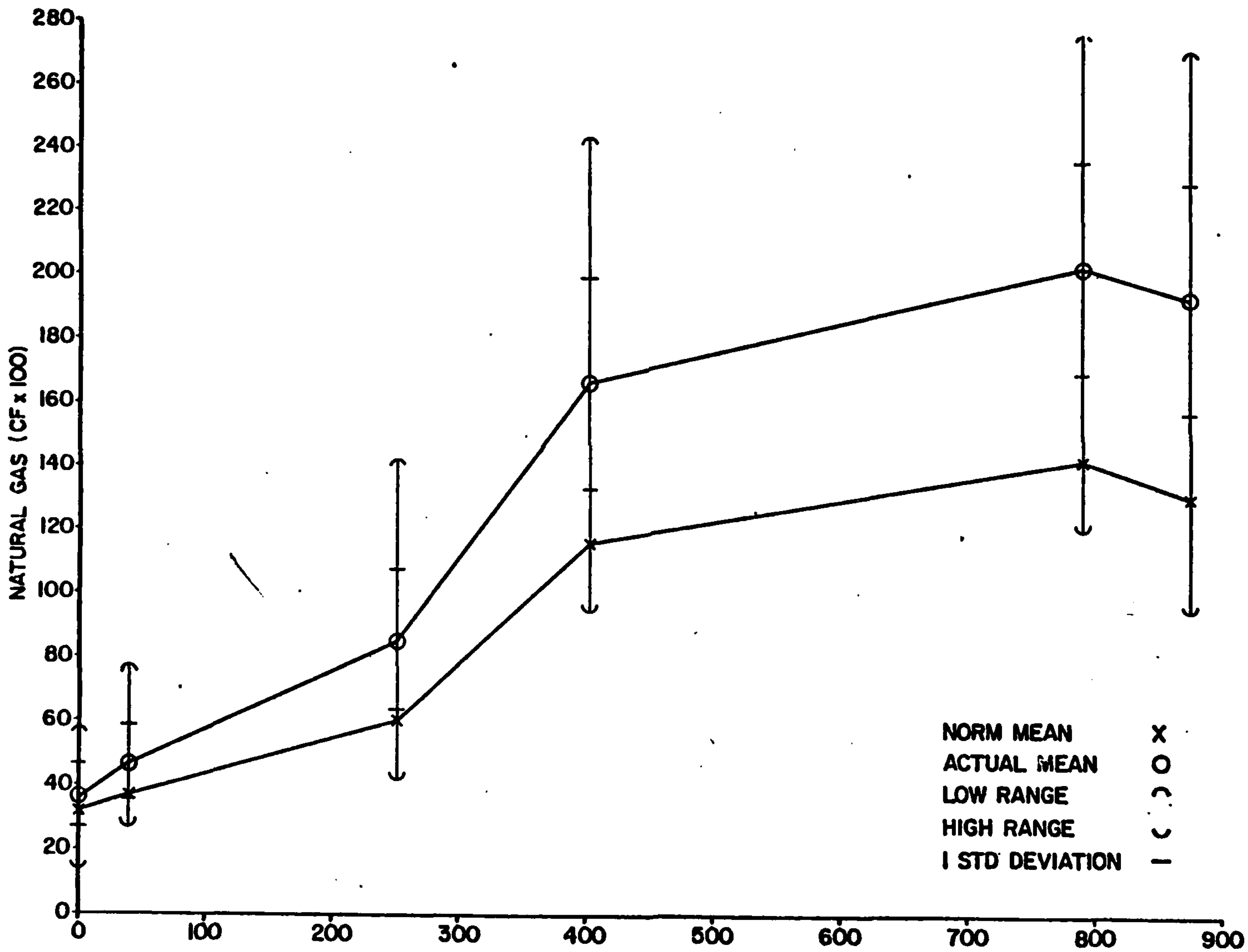

FIGURE 18 GAS CONSUMPTION AND NORMS VERSUS HDD (QUANTICO)

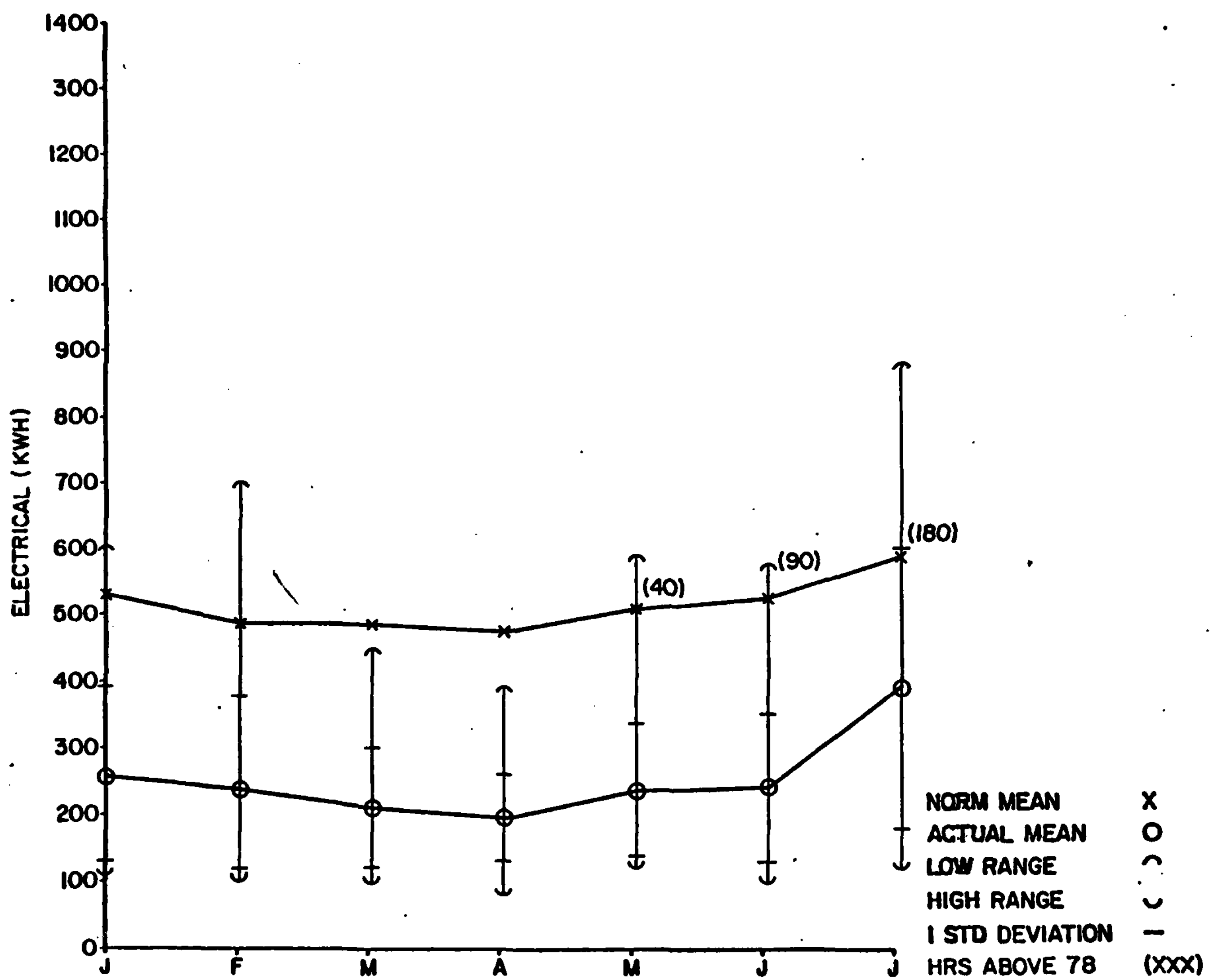

FIGURE 19 ELECTRIC CONSUMPTION AND NORMS VERSUS MONTHS (QUANTICO)

consumption meters or the meter conversion factor may be in error as the actual consumption is much too low for this type of unit. This is the widest variation that was found between actual and norm data in the family housing units. As in previous electrical consumption and norm figures, the differences in the summer months when cooling is required is less than that in the winter months, indicating greater use of the cooling system than predicted by the cooling algorithm.

Figure 20 shows the propane consumption and norms vs. heating degree days for this unit. Although the norm and the actual are very close together in the low heating degree day months, a larger difference is noted during the heating season. Although the two curves track each other nicely, the wide difference in norm and actual consumption cannot be explained without an on-site evaluation. Again, it appears as though a conversion factor of Btu's to pounds of propane may be an error or meters are being read incorrectly.

A third building type studied at Quantico was a 1277 SF, three bedroom unit containing 297 SF of windows. The single family, one-story, frame structure was built in 1962 and has an infiltration/conduction factor of 19,365. Figure 21 shows the electrical consumption for this group of buildings. Much wider variations in actual consumption are noted for this building than for the other two buildings observed at Quantico. It is again obvious in the summer months that the norm cooling algorithm tends to predict less than the actual consumption of the units.

Figure 22 shows the gas consumption and norms vs. heating degree days for this unit. In this unit, though the norm is slightly less than that

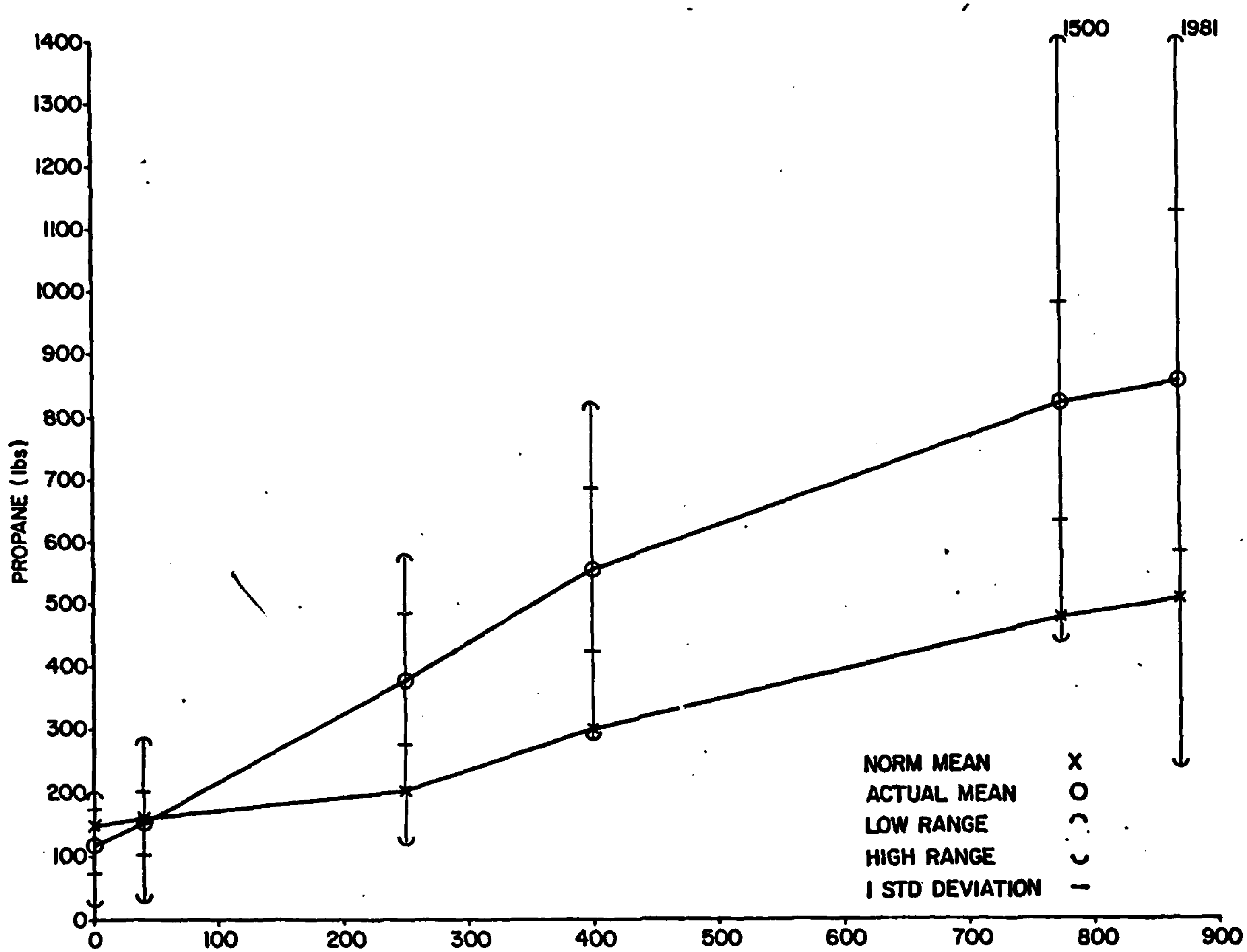

FIGURE 20 GAS CONSUMPTION AND NORMS VERSUS HDD (QUANTICO)

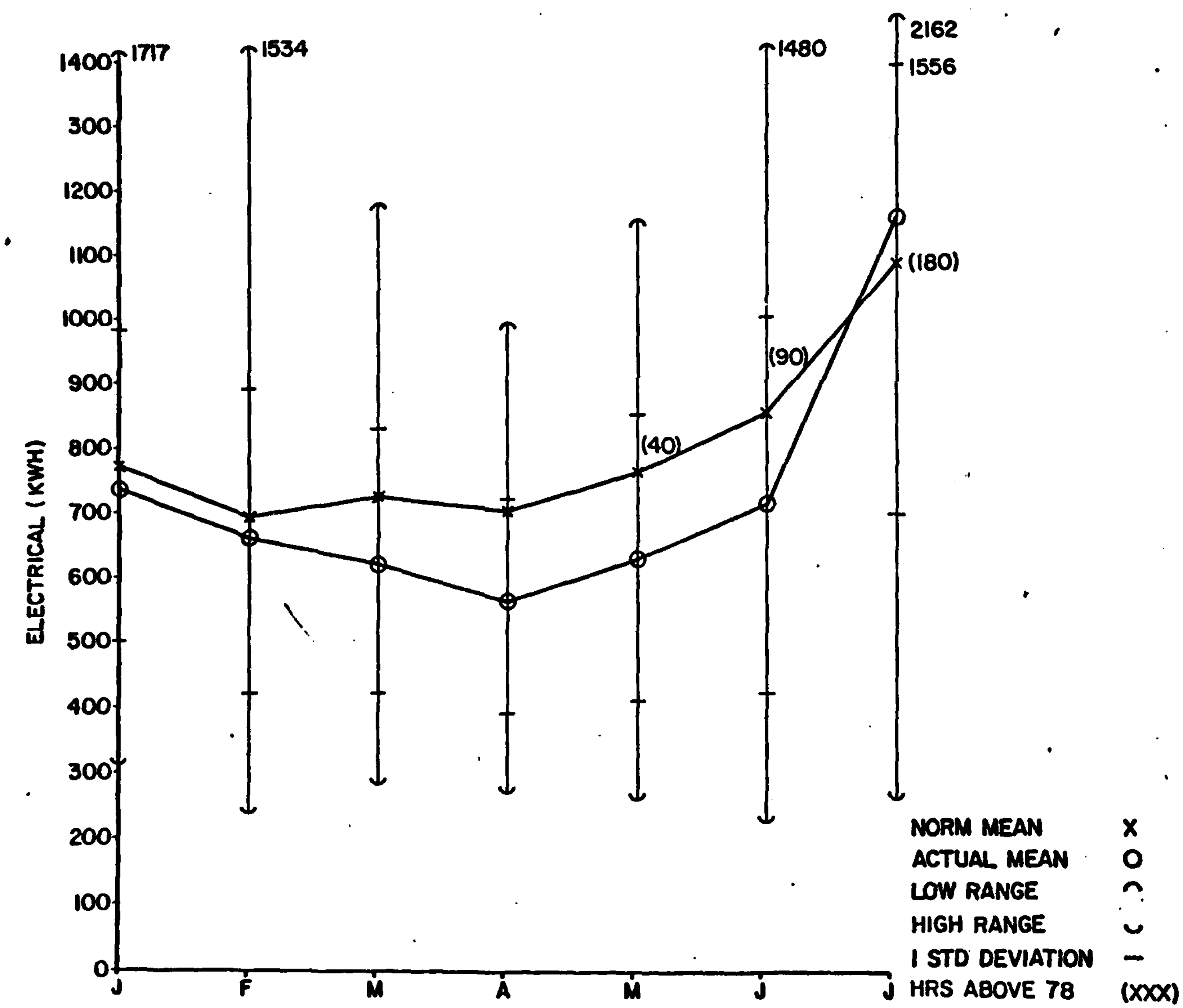

FIGURE 21 ELECTRIC CONSUMPTION AND NORMS VERSUS MONTHS (QUANTICO)

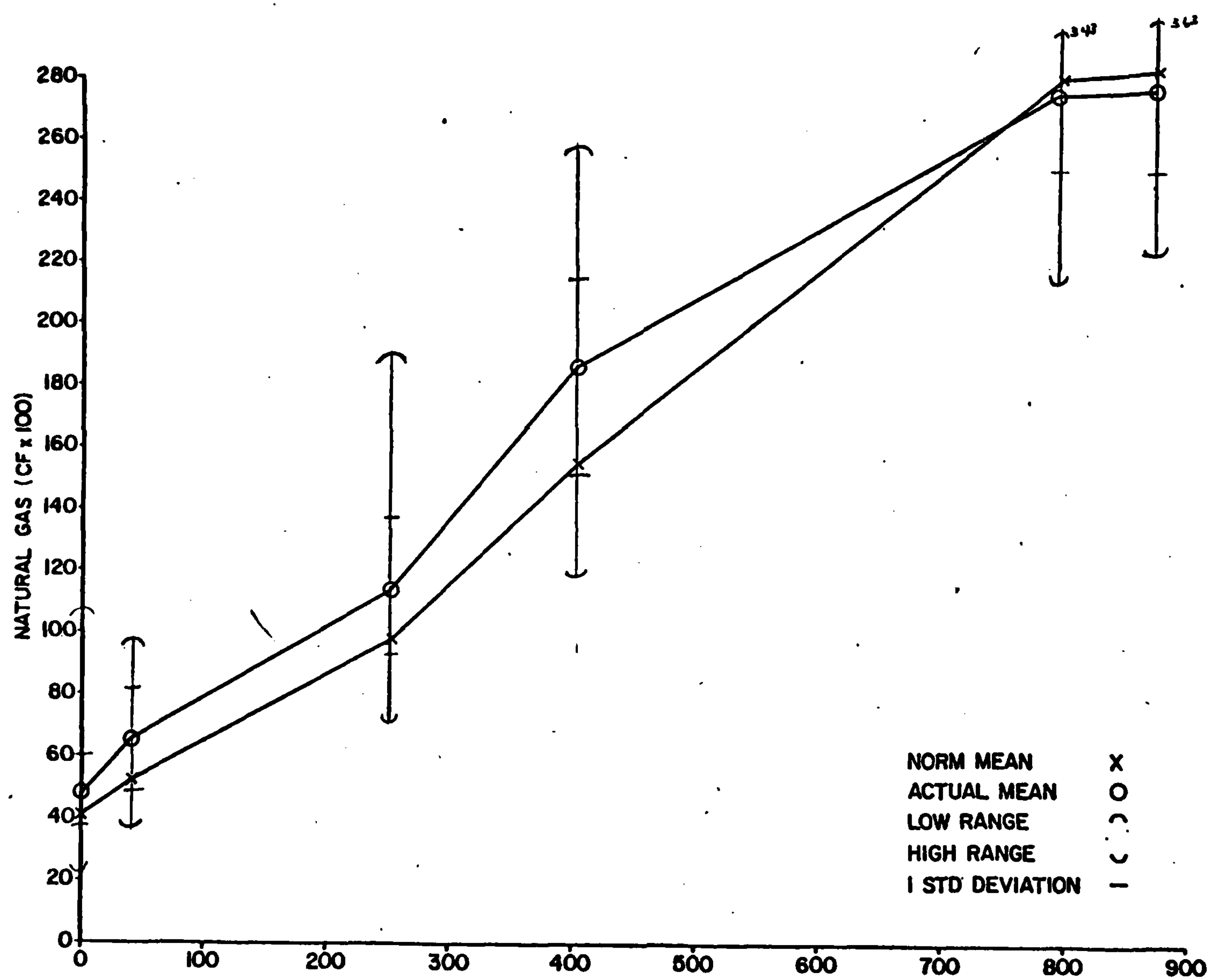

FIGURE 22 GAS CONSUMPTION AND NORMS VERSUS HDD (QUANTICO)

of the actual consumption for the majority of the period, it tracks the actual consumption extremely nicely and during the higher heating degree months, the actual consumption and the norm consumption are within 2-3%.

In observing the Quantico data, it can be seen that the electrical norm is lower than the actual for the two bedroom unit and higher than the actual for the three bedroom units, again suggesting the "number of bedroom" electrical norm may be incorrectly separated at the 2 and 3 bedroom levels. The second data case indicated on Figure 19 is assumed to be in error from the actual consumption data standpoint. In all cases, the gas consumption is higher than the norm predicted value. As mentioned previously, this could be due to any number of factors including higher indoor set point temperatures used by the occupants during the heating months, improper field calculation of infiltration/conduction factors or higher than actual furnace efficiency factors in the norm algorithm. The excellent tracking of norm and actual curves provides confidence that the heating algorithm equation form is correct.

Fort Gordon, GA

The next activity studied was Fort Gordon, GA, which has a total of 593 family housing accounts. Weather parameters during the monitoring period are shown on table 4. The family housing units are served by natural gas for heating, cooking, and hot water and have central electrical air conditioning units serving each unit. The first building type studied at Fort Gordon was a 1378 SF, frame, town house center unit. The two story, three bedroom unit was built in 1967, has a window area of 174 SF and an infiltration/conduction factor of 12,291. Figure 23 shows the electrical consumption for this sample of 86 thermodynamically equivalent units vs. the months of data collection. The numbers in parenthesis indicate the number of hours that the outdoor temperature exceeded 78^{o} F. It can be seen from Figure 23 that the norm mean is approximately 100 KWH higher than the mean of the actual consumption for these units. It is also seen that cooling is apparently not used within the building until the month of May. The cooling algorithm, however, calculates a cooling consumption whenever outdoor air temperature exceeds 78^{o}, as in March where 53 cooling hours are evident. This increase in the norm when the occupants are not utilizing cooling causes difference between the norm and actual consumption during the months of May and April. It is shown that after air conditioning is turned on in the facilities, the norm and the actual track very well for the remainder of the cooling season.

Figure 24 shows the natural gas consumption and norms vs. the heating degree days at Fort Gordon. As can be seen, the norm is slightly lower but very close to the actual consumption during the very low (less than 100) heating degree days but the variance increases to approximately

TABLE 4

WEATHER PARAMETERS

Activity: Fort Gordon

Month	Daily Heating Degree Days	Total Heating Degree Days	Hours Above 78°F	Temperature of Water Supply
JAN	19.83	615	--	49
FEB	17.28	484	--	49
MAR	6.19	192	53	58
APR	.40	12	128	66
MAY	.29	9	228	72
JUN	--		331	78
JUL	--		479	80
AUG	--		467	81

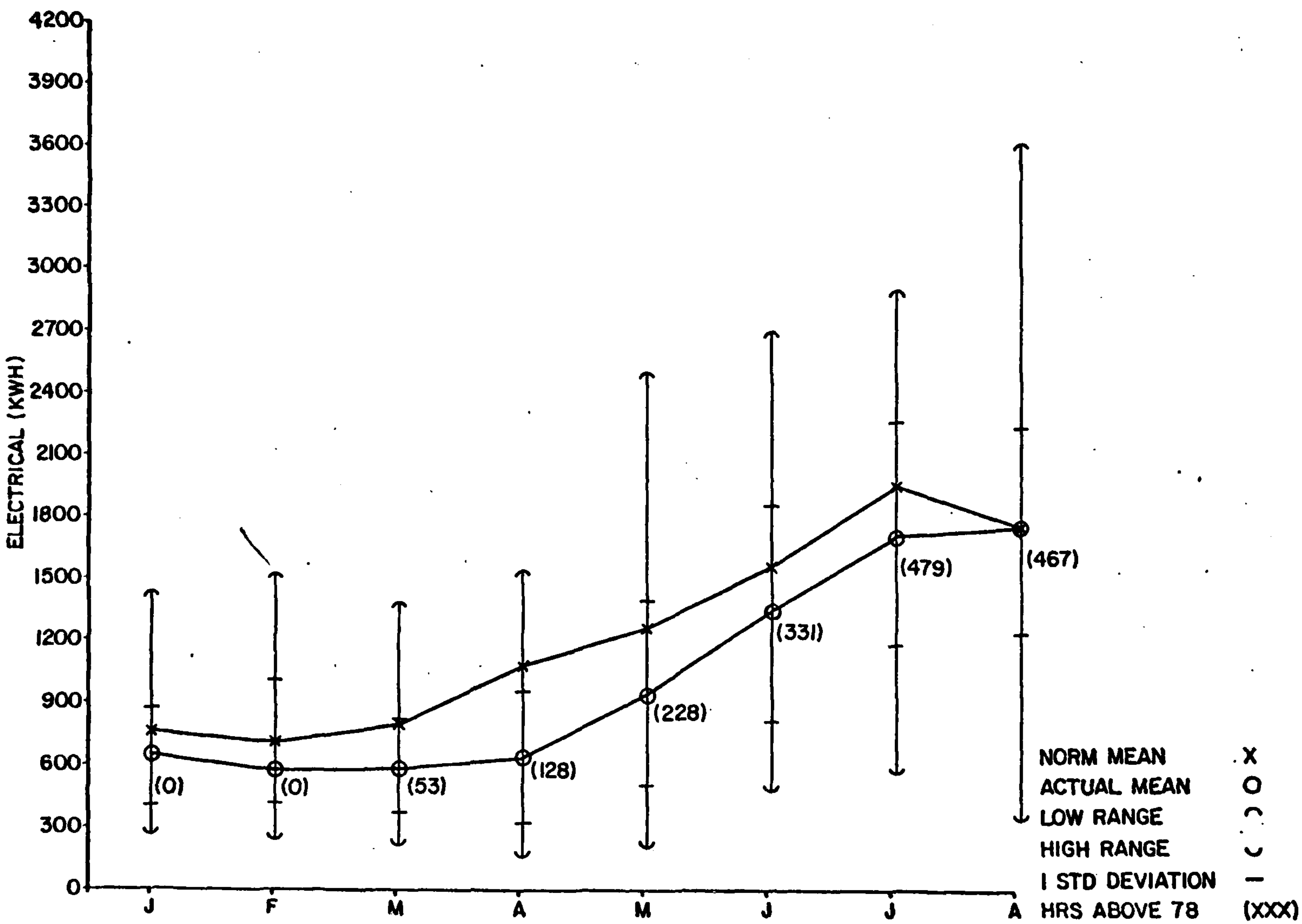

FIGURE 23 ELECTRIC CONSUMPTION AND NORMS VERSUS MONTHS (FT GORDON)

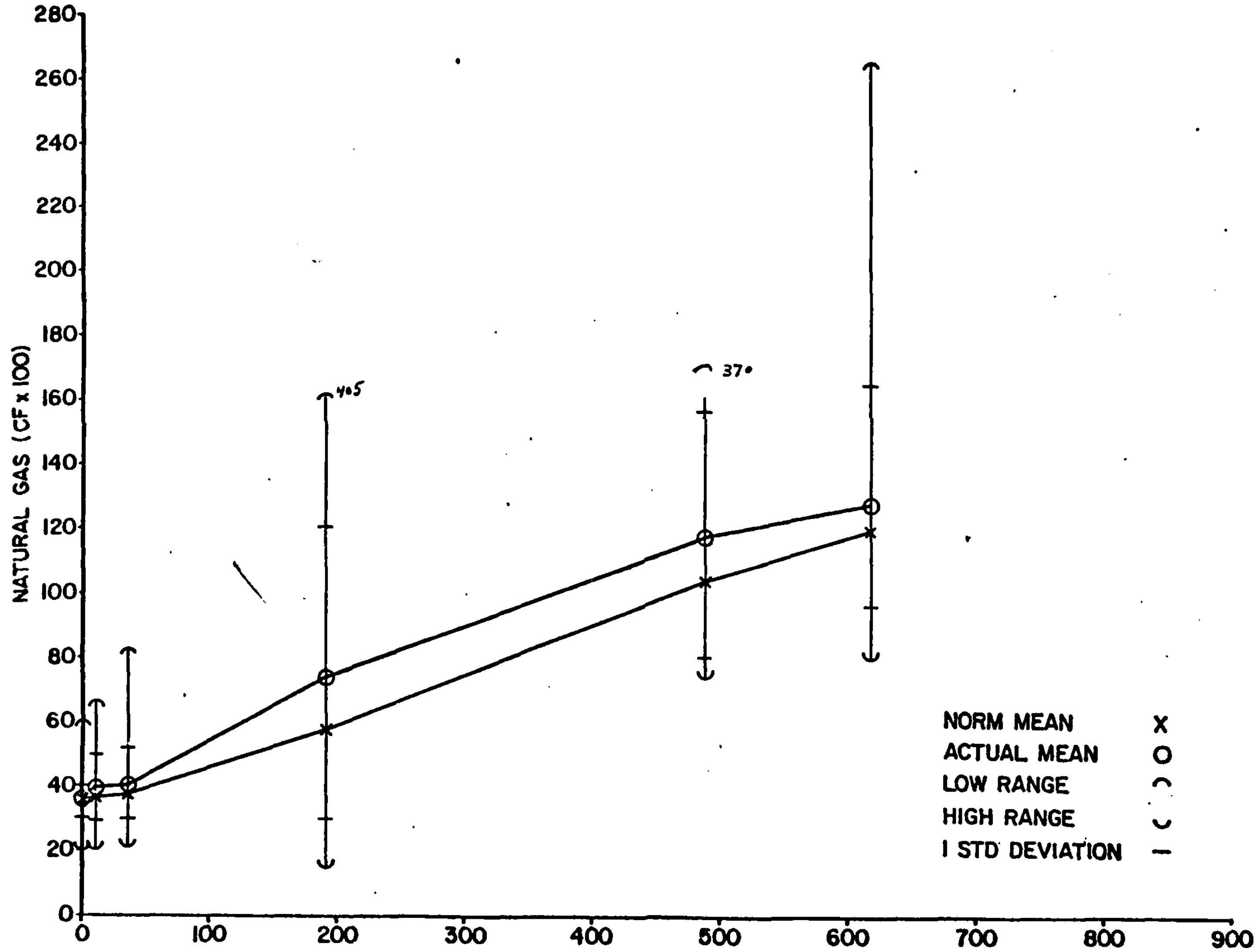

FIGURE 24 GAS CONSUMPTION AND NORMS VERSUS HDD (FT GORDON)

2,000 cubic feet for the remainder of the heating season. This could be due to factors as discussed earlier such as improper infiltration/conduction factors, higher than actual furnace efficiencies, or indoor set point temperatures exceeding 68° in the actual sample units.

The second building studied at Fort Gordon was an identical 1378 SF building. However, this was the end unit of the town houses. This frame structure also has three bedrooms, and its conduction/infiltration factor was 11,927. Figure 25 shows an electrical consumption and norms vs. the months for this building sample of 85 thermodynamicallly equivalent buildings. Once again, the trend is exactly the same as that shown on Figure 23 where the norm mean increases as the hours above 78° increase and the actual consumption does not begin increasing until May when the air conditioners are being used in the units. The same 100 KWH difference during the non-cooling hours is also evident with this building type indicating that the basic electrical norm is high for two and three bedroom buildings.

Figure 26 shows the gas consumption and norms for this sample of thermodynamically equivalent buildings. Again, Figure 26 is very much the same as Figure 24 where the norm is lower than the actual consumption but tracks it very nicely throughout the increase in heating degree days.

A final building studied for Fort Gordon was a 1556 SF town house end unit. This two story frame structure built in 1967 is a four bedroom unit with 217 SF of windows. It has an infiltration/conduction factor of 14,726. Figure 27 shows the electrical consumption vs. months and hours above 78° for this facility. It can be seen that this building's actual mean consumption during the non-cooling months is approximately 100 KWH

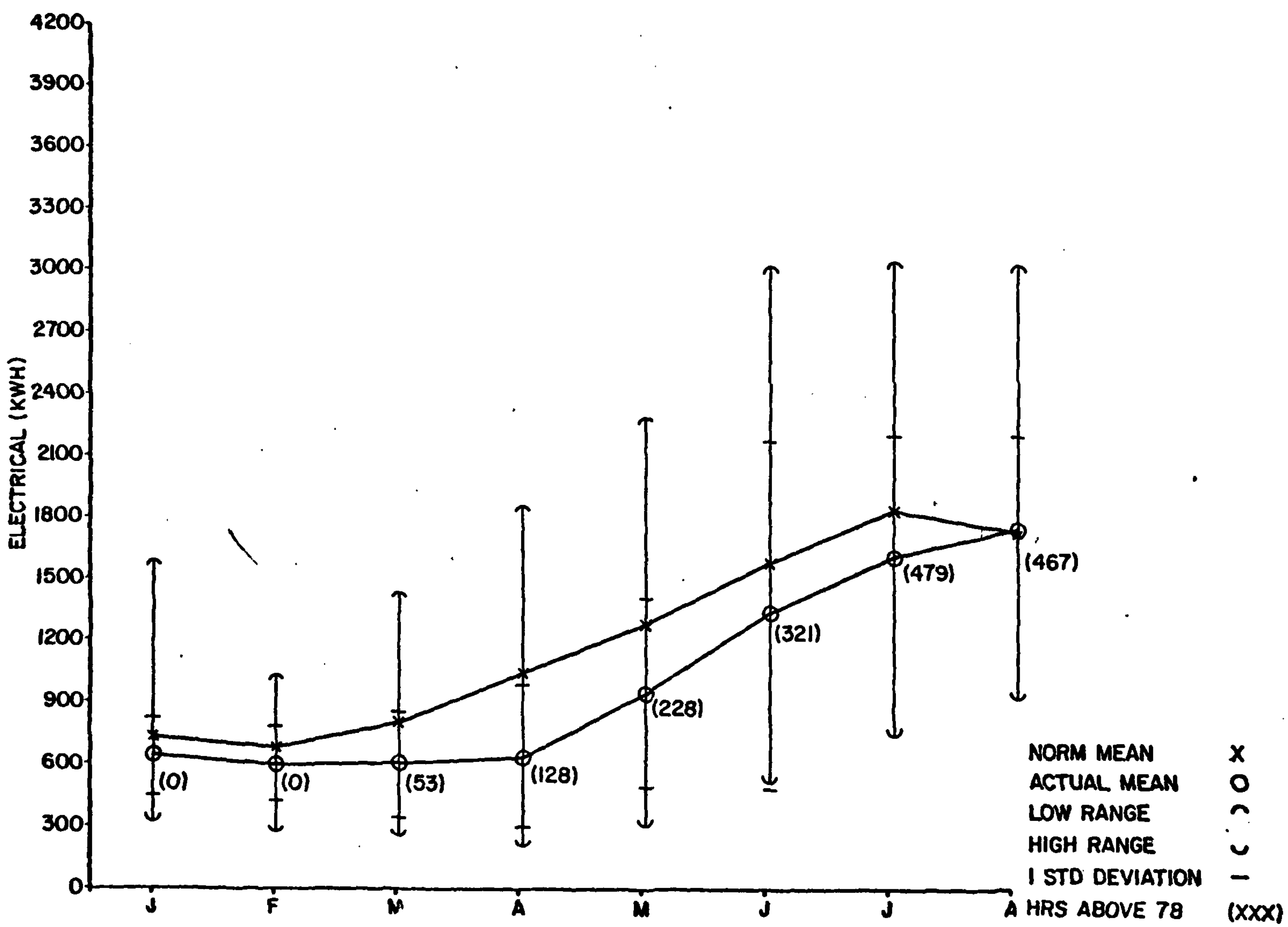

FIGURE 25 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (FT GORDON)

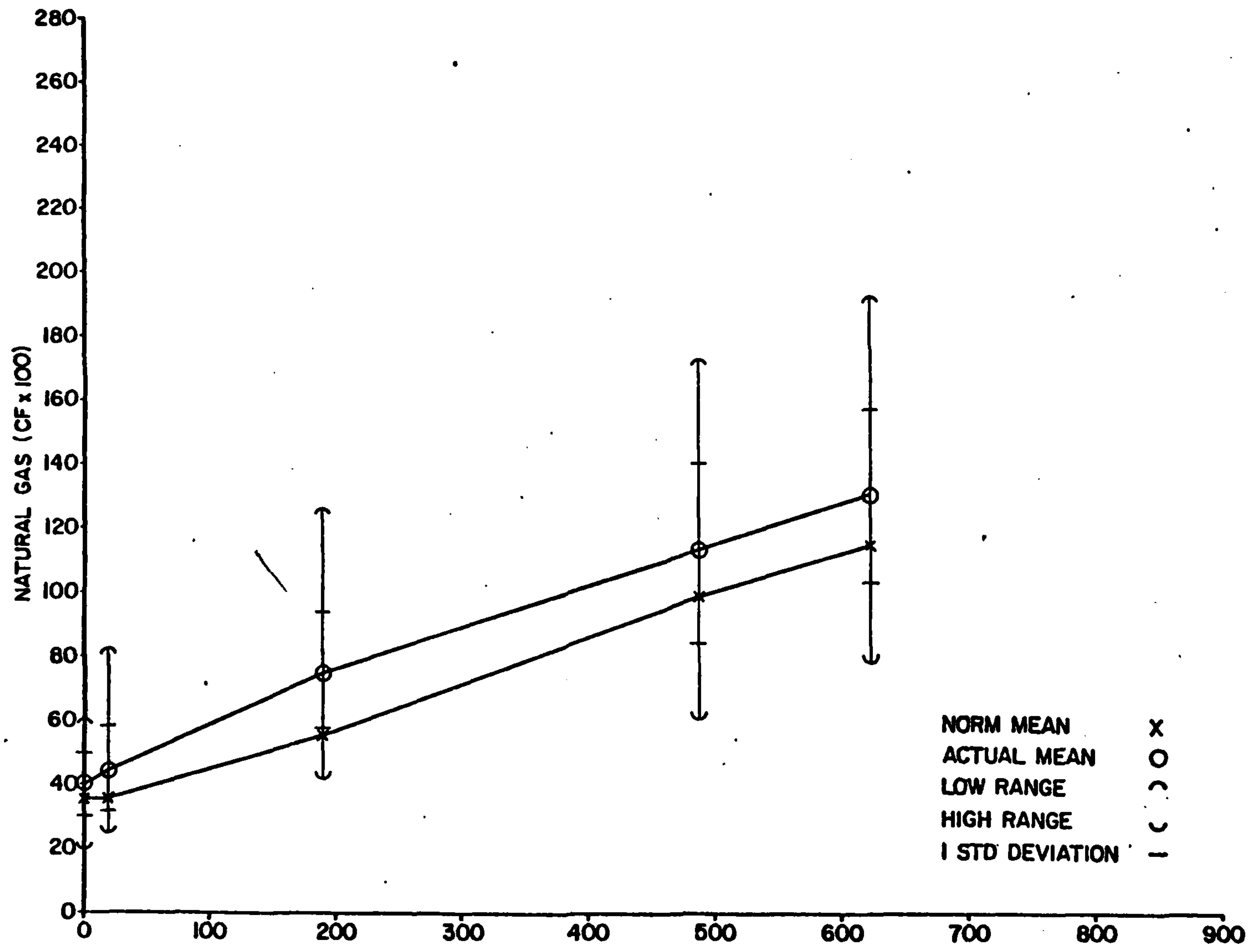

FIGURE 26 GAS CONSUMPTION AND NORMS VERSUS HDD (FT GORDON)

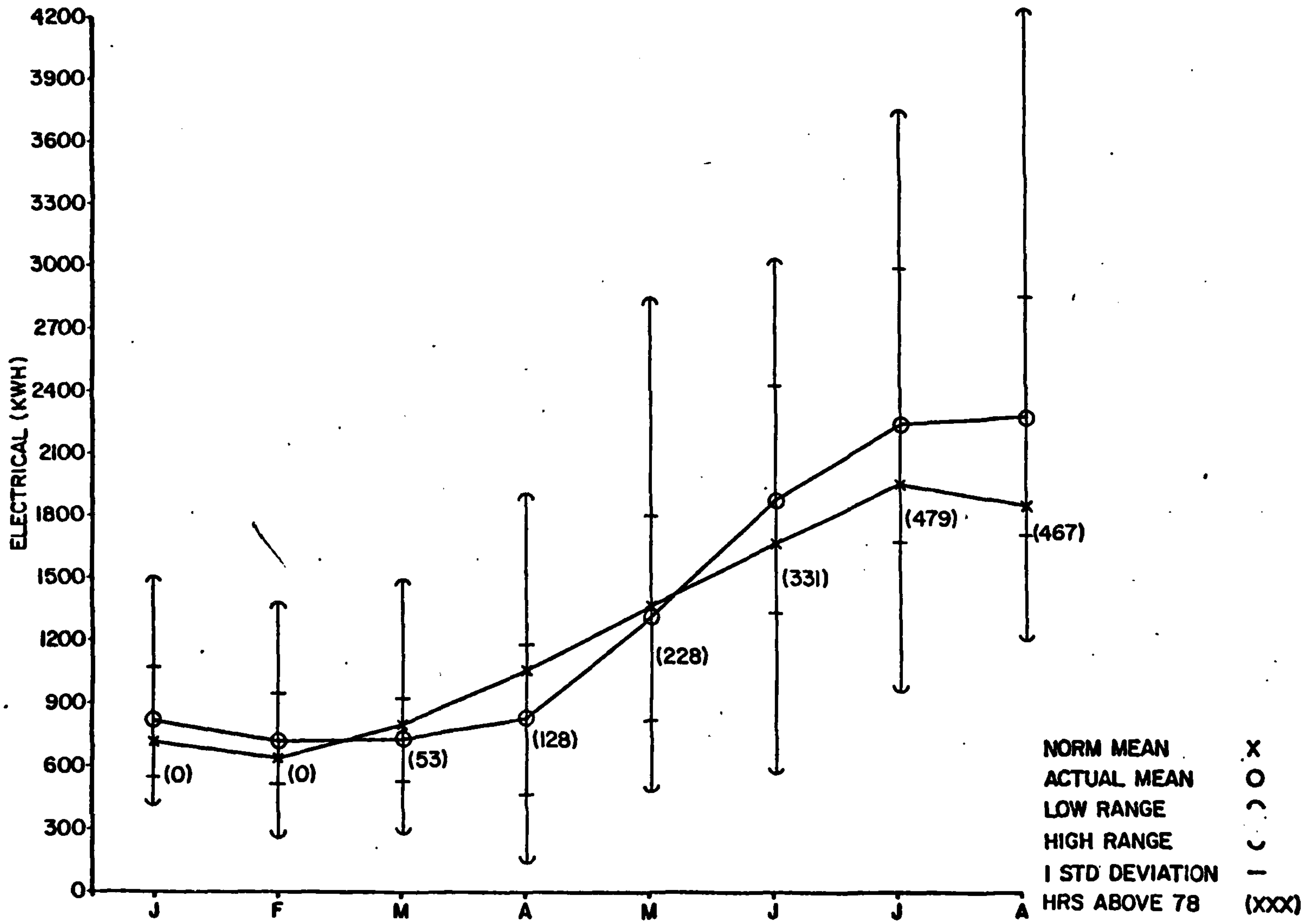

FIGURE 27 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (FT GORDON)

higher than the norm calculated value until cooling hours begin to increase the norm. It can again be seen that the air conditioning is not utilized to any significant degree until May. The curve indicates that after air conditioning is being utilized the actual consumption increases faster than the consumption predicted by the norm cooling algorithm suggesting lower indoor set points than 78° F.

Figure 28 shows the gas consumption and norm vs. heating degree days for this sample of 68 thermodynamically equivalent buildings. This figure is very similar to Figures 24 and 26 where the gas consumption in the very low heating degree day months is very close to the norm but the variance becomes greater than the actual consumption for the remaining period of higher heating degree days.

Little Rock AFB, AR

The last activity studied was Little Rock AFB, AR. Little Rock AFB has a total of 1,538 family housing units. Weather parameter for this activity are shown on Table 5. The family housing on this activity is totally electric, utilizing electricity for heating, cooking, cooling, and domestic hot water heating.

The first building studied was a 940 SF frame duplex built in 1958. The two bedroom, one-story structure contains 115 SF of window area and has an infiltration/conduction factor of 6,504. Figure 29 shows the electrical consumption and norms by month for this sample of 323 thermodynamically equivalent buildings. In addition to the number of hours above 78° during the monitoring period, the bracketed number indicates the total number of heating degree days during the month. The curves

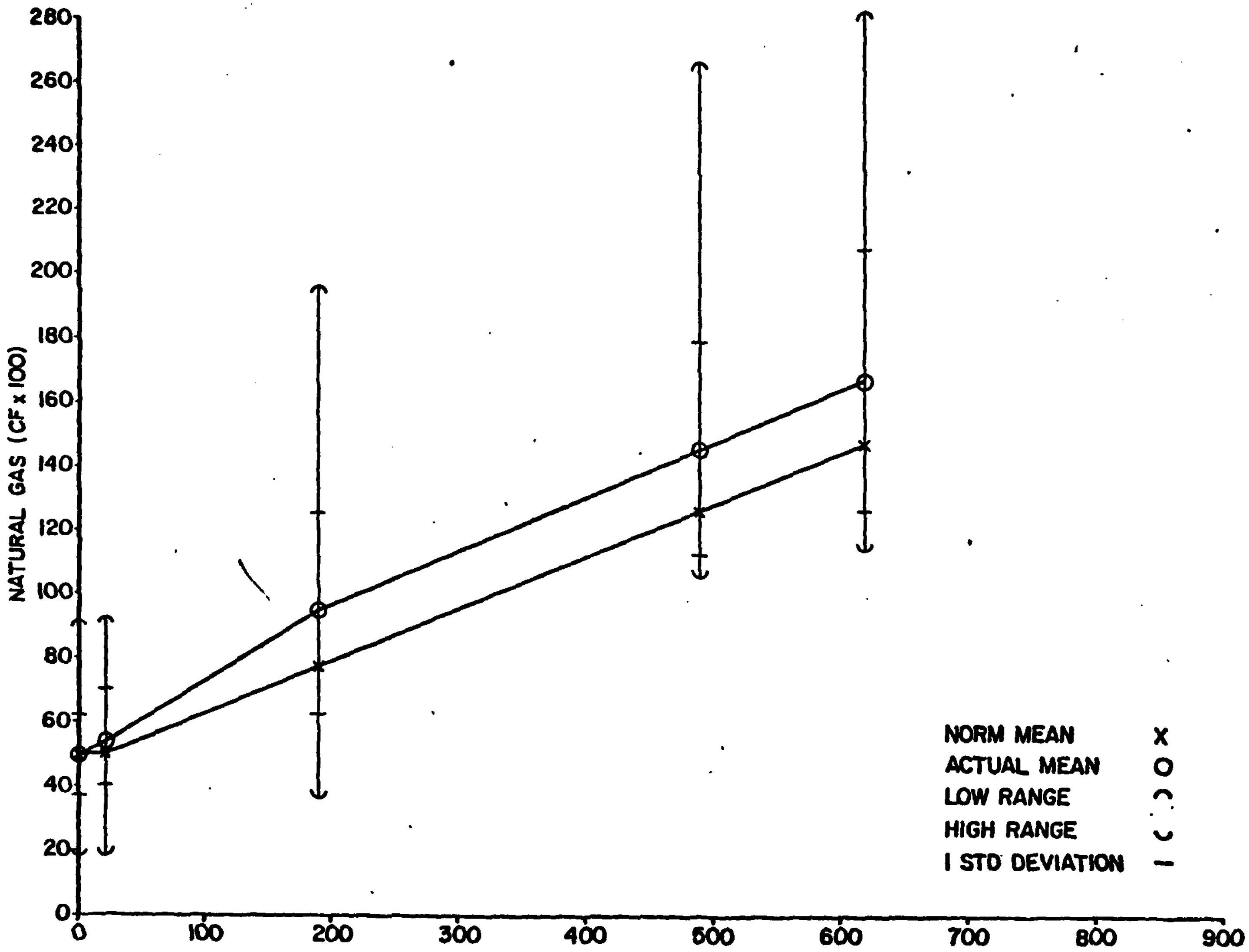

FIGURE 28 GAS CONSUMPTION AND NORM VERSUS HDD (FT GORDON)

TABLE 5

WEATHER PARAMETERS

Activity: Little Rock AFB

Month	Daily Heating Degree Days	Total Heating Degree Days	Hours Above 78°F	Temperature of Water Supply
JAN	37.09	1150	--	44
FEB	28.64	802	--	44
MAR	11.90	369	--	53
APR	5.96	179	30	61
MAY	1.51	47	87	65
JUN	--		250	72
JUL	--		354	76
AUG	--		298	77

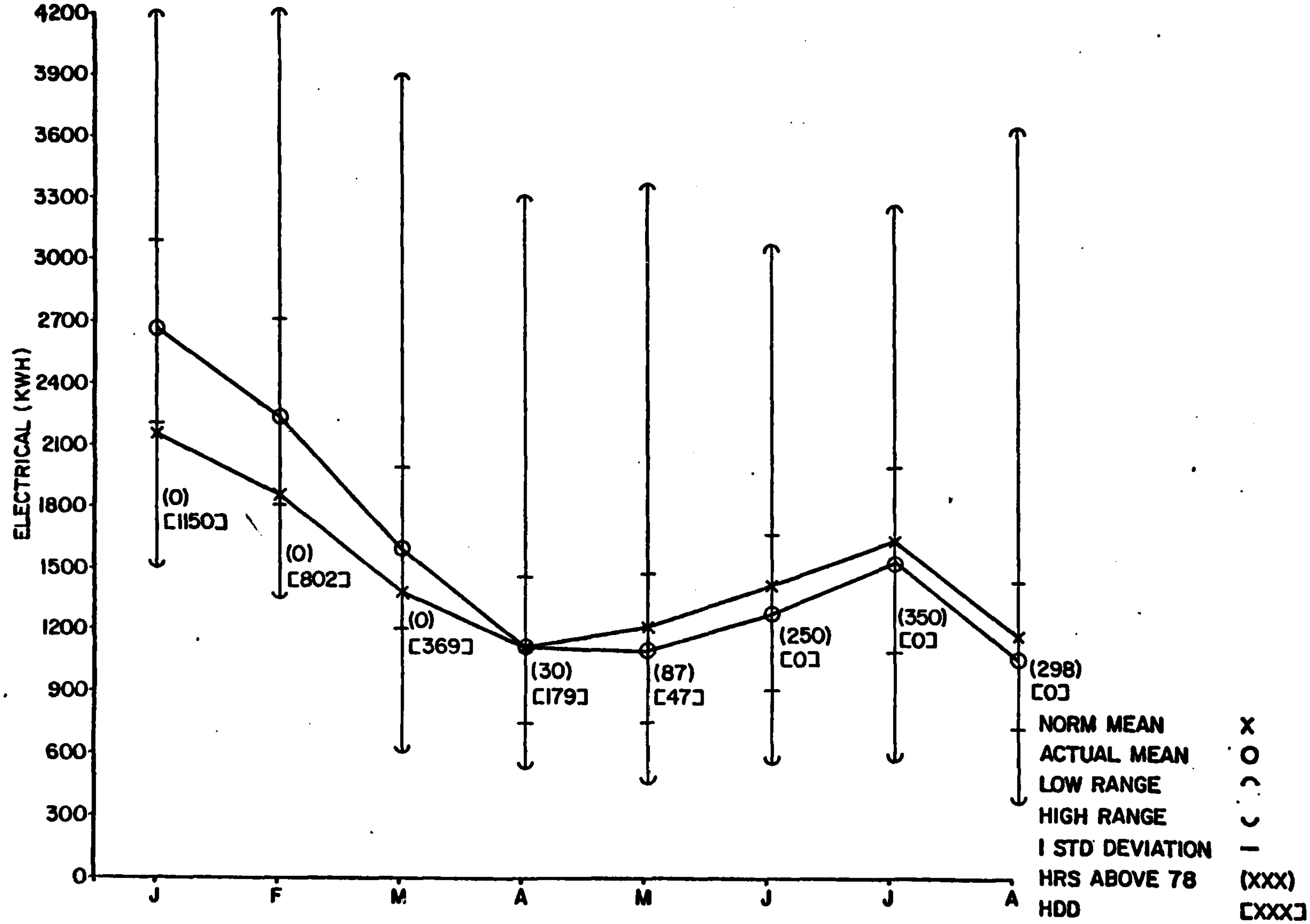

FIGURE 29 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (LITTLE ROCK AFB)

shown on Figure 29 are slightly more complex to analyze than those previously shown. It can be seen during the heating months that the actual consumption is higher than the norm consumption but tends to merge together and become lower than the norm when heating is no longer required and cooling becomes a significant portion of the electrical load. During the cooling months, the norm consumption is higher than the actual mean consumption by about 10%. It is noticed that the two curves track very nicely for the heating periods and cooling periods, individually. The wider variance between the norm and actual in January vs. that in March and April is due to the heating system coefficient of performance (reciprocal of efficiency) for the heat pumps in the facilities. A constant heat pump coefficient of performance was used in the calculations of the norm. Since heat pumps are more efficient in warmer months, a variable coefficient of performance based on the number of heating degree days should be developed and added to the norm calculations procedure to more accurately calculate the consumption in the building.

The second building studied at Little Rock AFB is a 1,052 SF single story duplex. This three-bedroom frame has 142 SF of window area and has an infiltration/conduction factor of 7651. Figure 30 shows the total electrical energy consumption and norms versus heating degree days and hours above 78°. This curve is very similar to that shown in Figure 29 where the actual consumption is higher than the norm consumption during the heating months and lower than the actual consumption during the cooling months. This indicates the same conclusion that the total norm algorithm predicts too high for heating and too low for cooling at this installation.

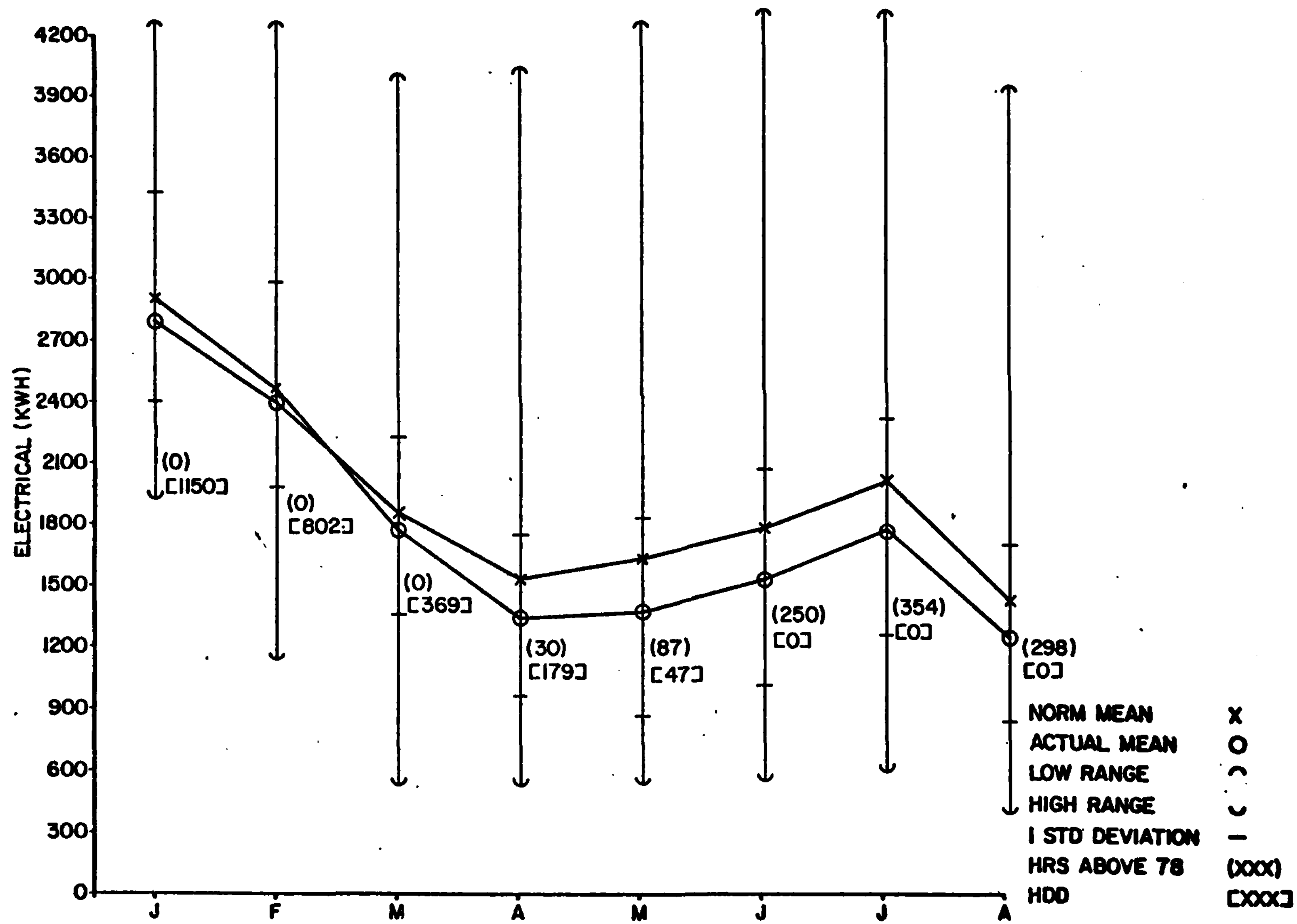

FIGURE 30 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (LITTLE ROCK AFB)

The fact that the two curves track each other nicely indicates that minor adjustments to the norm algorithm can be made to decrease the variance between norm and actual.

The third building studied at Little Rock AFB is a 1078 SF three-bedroom duplex built in 1958. This single story frame structure contains 142 SF of window area and an infiltration/conduction factor of 7748. Figure 31 shows an electrical consumption in norms for this group of thermodynamically equivalent sample of buildings containing 268 cases. The same trends are evident in this curve as in the other two previous curves for Little Rock AFB, an underprediction during the heating months and an overprediction during the cooling months.

DOMESTIC HOT WATER

An analyses of family housing actual consumption data during non-heating and cooling months was accomplished to determine the effects of the number of occupants in a unit on domestic hot water usage. Tables 6 through 8 show the tabulated data for three actvities. Each group of units selected were thermodynamically equivalent to eliminate differences in energy usage caused by varying building parameters.

Table 6 shows data for Little Rock AFB. This activity is totally electric, so the monthly consumption values include lighting and appliance usage. Since little heating or cooling was utilized during the months of April, May and June, the difference between the usage of groups of units having different occupancy should accurately reflect the

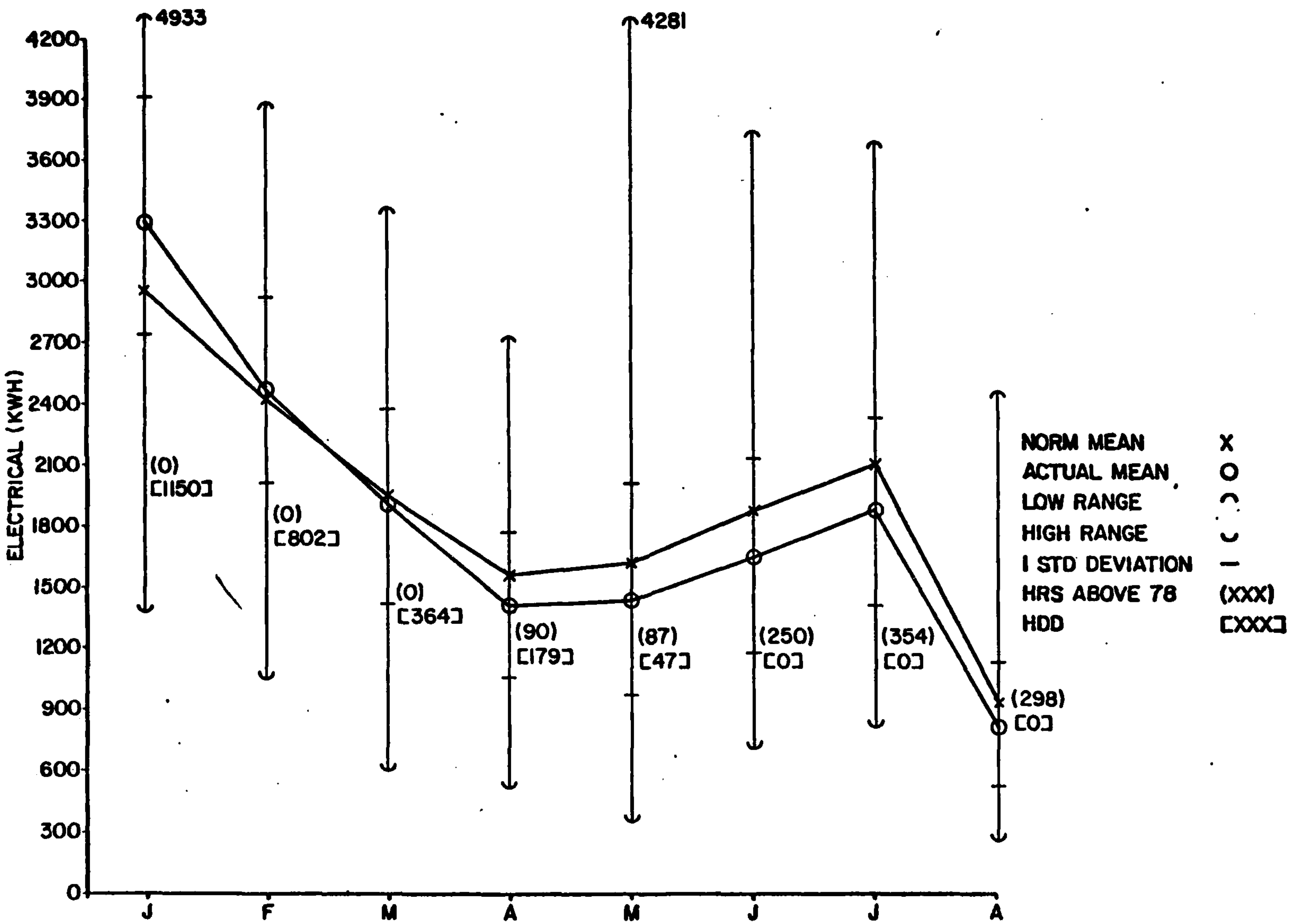

FIGURE 31 ELECTRICAL CONSUMPTION AND NORMS VERSUS MONTHS (LITTLE ROCK AFB)

TABLE 6

ENERGY USAGE VERSUS OCCUPANCY

Activity: Little Rock AFB

No. of Occ.	Actual Consumption (KWH) April	May	June	Average Consumption (KWH)	Increase per Occupant	Sample Size
2	1200	1178	1314	1230	--	52
3	1247	1265	1446	1319	89	106
4	1314	1347	1536	1399	80	193
5	1470	1546	1658	1558	159	75
6	1571	1677	1838	1695	137	24

domestic hot water incremental electrical energy use. As can be seen from the table, the average increase in consumption per unit from 2 to 3 and from 3 to 4 occupants is 80-90 KWH. Observing the changes from 4 to 5 and 5 to 6 occupants, the increase is 159 and 137 KWH respectively. The norm algorithm for the hot water heating energy requirements predicts a constant 145 KWH increase per occupant for the average supply water temperature of 74°F during this period. This indicates that the domestic hot water norm which allows 25 gallons of 140°F hot water per person will be consistently over generous in its energy allowance. This can also be seen graphically on figures 30 and 31 which indicate a norm approximately 200 KWH higher than actual consumption during April, May, and June at Little Rock AFB.

Table 7 shows data for Cannon AFB. This activity uses natural gas for domestic hot water heating. During the minimal heating months of May June and July the data reflects the actual consumption for pilot lights, minimal heating, cooking, and domestic hot water energy use. This table shows an increase in energy requirements from 2 to 3 occupants of 260 cubic feet (CF) of natural gas. Larger amounts of energy are used when occupancy changes from 3 to 4 occupants (460 CF) and from 4 to 5 occupants (620 CF). The average calculated norm increase per occupant for Cannon AFB during this time period, is 620 CF. The domestic hot water norm again will tend to be generous in its allowance for domestic hot water

TABLE 7

ENERGY USAGE VERSUS OCCUPANCY

Activity: Cannon AFB

No. of Occ.	Actual Consumption(CFX100) May	June	July	Average Consumption (CFX100)	Increase per Occupant	Sample Size
2	42.3	33.8	33.1	36.4	--	35
3	47.0	36.4	33.5	39.0	--	55
4	54.8	40.1	36.0	43.6	2.6	48
5	65.9	46.9	36.7	49.8	6.2	20

heating energy. This high trend is also shown on Figures 8, 13, and 15. Where the norm consumption for low heating degree day months is higher than the mean of the actual consumption.

Table 8 shows the natural gas consumption for Fort Gordon, GA during the non-heating months. The data again reflect the actual usage for pilots, cooking and domestic hot water heating. Data for this activity does not show any significant variance in energy use for family housing units for occupancies ranging from 2 to 4 occupants. However, as occupancy increases from 4 to 5 occupants, an increase of 450 CF of natural gas is observed. Likewise, as occupancy increases from 5 to 6 occupants, an average increase in natural gas consumption of 390 CF is shown. The calculated average hot water norm for this activity and time period is 540 CF per occupant in the units. This will cause the norm to be inaccurate as the number of occupants in a unit increase.

The analysis of energy usage vs. occupancy indicates the hot water norm will tend to be only high for family housing units with a large number of occupants. Energy usage for domestic hot water between 2 and 3 occupants does not substantially increase. Also a lower increase in energy usage due to domestic hot water is evident between 3 and 4 occupants than for occupancies greater than 5. These tendencies would indicate that an additional variable (such as occupant age) may be necessary to accurately predict domestic hot water energy consumption.

TABLE 8

ENERGY USAGE VERSUS OCCUPANCY

Activity: Fort Gordon

No. of Occ.	Actual Consumption (CFX100) May	June	July	Average Consumption (CFX100)	Increase per Occupant	Sample Size
2	38.9	35.4	35.6	36.6	--	17
3	39.3	35.4	34.6	36.4	--	26
4	38.6	36.2	35.0	36.6	.2	24
5	42.0	39.6	41.6	41.1	4.5	20
6	47.0	42.5	45.5	45.0	3.9	15

Summary

The heating and cooling loads in family housing depend on the interrelationship of many variables. Among these are outdoor temperature, indoor set point temperature, insulation levels of the walls, roof, and floor, amount of windows, amount of outdoor leakage, amount and usage of lights and appliances, heating and cooling system efficiencies and number and life style of occupants.

Outdoor air temperature is used in the norm algorithm in the form of heating degree days for heating, and number of hours the outdoor temperature exceeds 78°F for cooling. The excellent tracking of the norm, and actual consumption for the buildings analyzed, indicate that the weather parameters used in the norm algorithm properly predict trends in heating and cooling requirements.

The indoor set point temperature or the actual thermostat setting within the military family housing unit is a noncontrollable item from the norm algorithm standpoint. The norms were developed by utilizing a constant 68°F indoor set point for heating and 78°F for cooling. Variations from these set points in the actual units would increase the energy used for heating and cooling. Other studies have shown that a 1°F increase in the heating set point, can cause up to a 3 percent increase in energy usage. It is suspected that many of the family housing units are enjoying temperatures greater than 68°F in the heating season and lower than 78°F in the cooling season.

The insulation levels of the walls, roof, and floor, and amount of air leakage in the building, are taken into account by the infiltration/conduction factor that was calculated for each family housing unit in the test metering program. Training and instructions were provided to the survey teams for calculating this important parameter. In the early stages of the program, several of the activities were found to have made errors in their calculations. The gross errors were easily detected, but a method should be developed to insure that accurate calculations of this parameter are accomplished. The conduction/infiltration factor is directly related to the energy consumption and calculated norm of the family housing unit. A 5 percent error in its calculation would produce a corresponding 5 percent variation in the norm calculation.

The heating and cooling system efficiencies for the test metering program were selected from data available in reports published by the National Bureau of Standards and appear to be rather stringent. (A higher than actual efficiency will cause the calculated norm to be low). For the test program, a constant annual efficiency was selected for heating systems and cooling systems. It has been shown on the curves presented herein, that the efficiencies do change based on the amount of usage of the system or as heating degree days or hours above 78° increase. This is evident from curves such as Figure 2 where the variance between the norm and actual consumption is wider in the lower heating degree months than in the higher heating degree months. This indicates a higher efficiency during cold months and a lower efficiency during warm months.

Further analyses of the actual data and more research into family housing system efficiencies is required to completely define the seasonal variations of family housing system efficiencies which can be utilized in the programs to produce a more accurate norm. Since the occupant does not have direct control of this variable, the norm should be designed to provide the most reasonable estimate of heating and cooling system efficiences and the efficiencies may need to be adjusted on an activity by activity basis.

The number and life style of occupants remain the most unpredictable parameter in the norm development. It was shown on Table 6 through 8 that even the increase in usage among thermodynamically equivalent units with different occupancy does not follow consistent patterns. The curves shown previously indicate wide variations in the minimum and maximum consumption in units that are thermodynamically equivalent. Refinements can be made to the norm algorithm to allow a better prediction of electrical domestic hot water heating and cooling energy requirements. However, wide fluctuations in actual usage will still exist due to the occupants individual life styles and corresponding usage of energy.

The test metering program and analysis of actual data have uncovered areas that require further study prior to the complete implementation of a Family Housing Metering and Excess Billing System throughout DOD. Further analysis of actual energy use data and testing of heating and cooling systems to determine actual operating efficiencies and efficiency variation due to operating hours should be performed. A detailed training program should be developed to insure family housing

survey teams are sufficiently trained to perform the surveys select and group thermodynamically equivalent buildings and calculate infiltration/ conduction factors consistently for all activities. A time schedule for implementation at each activity should include up to a one year testing period to allow for refinements to the norm and achieve total fairness to all participants.

SAI-176-79-932-LJ

THE UTILITY NORM ANALYSIS TASK OF THE ENERGY CONSERVATION PROGRAM

FINAL REPORT

10 December 1979

Prepared for:

Department of the Navy
Naval Personnel Research
and Development Center
San Diego, California 92152

Under Contract No.
NOO-123-78-C1019

Prepared by:

Science Applications, Inc.
1200 Prospect Street
La Jolla, California 92038

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P.O. Box 2351, 1200 Prospect Street, La Jolla, California 92037

8 January 1980

Naval Facilities Engineering Command
Attn: Code 081B (Cdr. William Simmons)
200 Stovall Street
Alexandria, VA 22332

Dear Cdr. William Simmons:

This letter is in response to your request for additional information regarding the Utility NORM Analysis.

As it now exists, the NORM algorithm is not capable of addressing situations where space conditioning requirements are satisfied by a central plant. Before a NORM can be fully implemented, it must have that capability.

Regarding the accuracy of the NORM, it should be noted that the results of predictions versus experimental outcomes reported are based on incomplete experimental information. Default values were used for those parameters for which information was missing. However, despite this drawback the comparisons are considered to be very good, particularly in light of the limited sample size and short test period.

If it is assumed that the residences are in accordance with the as-built drawings and are in a proper state of repair and if the meteorological data is of good quality, then the energy consumption predicted by the NORM for a given set of behavior characteristics can be expected to be within 15% of the actual consumption. This tolerance accounts for the facts that a residence cannot be characterized with absolute accuracy, that the hourly weather variations are accounted for by simple models, and that peoples' living patterns cannot be modeled with absolute precision. Additional errors can be introduced if the houses are improperly constructed or if inaccurate or insufficient data is used.

This discussion of accuracy is based on the assumption of a 30 day billing period. It is expected that accuracy would decrease if the billing period were less than 30 days.

Regarding the evaluation of energy conservation modifications, it should be noted that the conclusions are based on a sampling of typical housing units at three different sites. To a varying degree, these units were already constructed with energy conservation in mind.

Science Applications, Inc. 1200 Prospect St., P.O. Box 2351, La Jolla, Ca. 92038, 714/459-0211

Other SAI Offices: Albuquerque, Ann Arbor, Arlington, Atlanta, Boston, Chicago, Huntsville, Los Angeles, McLean, Palo Alto, San Diego, Sunnyvale, and Tucson.

At Great Lakes, the typical housing unit used had an attic and the ceiling already had R-19 insulation installed. At Port Hueneme, the typical unit had an attic and the ceiling had R-9 insulation installed. At Fort Hood, the unit had no attic and the roof had no insulation.

The conclusions drawn concerning improvements in thermal characteristics of roofs and floors should be further explained. For cases where attics exist and ceilings are adequately insulated, improving the thermal characteristics of the attic roof does not contribute significantly to reduction of heating loads. Further, improving the thermal characteristics of the ceiling will reduce heating loads. Where no attics exist, improving the thermal characteristics of the roof will significantly reduce heating loads. For floors where a basement or crawl space exists, improving the thermal characteristics of the floor will result in reduced heating loads. Since all three sample houses were slab on grade this conclusion is not supported by our analysis.

In general, for primitive houses (i.e., no insulation, high air infiltration, no storm windows) reducing air leakage will result in the largest energy savings. Insulating the roof or ceiling, the walls, and floor where possible will result in significant energy savings. Ceiling insulation should have a higher R-value than wall insulation. Also, adding storm windows and doors will further reduce energy consumption.

If you have any further questions, please don't hesitate to call me at (714) 454-3811.

Sincerely,

SCIENCE APPLICATIONS, INC.

Steve Klein

Steve Klein
Principal Investigator
Navy Energy Conservation Program

SK/js

10 December 1979

Naval Personnel Research and
Development Center
San Diego, CA. 92152

Attn: Code P 307 BF, E. Somer

Subj: Contract N00123-78-C-1019
Completion of Line Item 0002AC

Gentlemen:

This letter is to verify delivery of CDRL Item A010, The Norm Analysis Task of the Energy Conservation Program. This deliverable completes all requirements of Task B, Line Item 0002AC, of subject contract.

If there are any questions or if further information is required, please contact the undersigned at (714) 454-3811, ext. 2111.

Sincerely,

SCIENCE APPLICATIONS, INC.

K. Jeff Houston, Manager,
System Group Contracts

cc: NPRDC, Code P 307 BF,
R. Morrison (1 copy)

NAVFAC, 200 Stovall Street
Alexandria, VA 22322
Attn: Code 082, Robert Sykes (5 copies)

Office of Asst. Secretary of Defense
Mr. T. R. Casberg
The Pentagon - 3E763
Washington, D.C. 20401 (1 copy)

Department of the Army
Construction Engineering Research Laboratory
CERL-EH/L. Windingland
P. O. Box 4005
Champaign, IL 61820 (1 copy)

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1. INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

The Military Construction Authorization Act of 1978, Public Law 95-82 authorized funding and directed the Secretary of Defense to establish reasonable ceilings for the consumption of energy in military family housing equipped with consumption meters, and to assess occupants a charge for metered energy consumption above the established ceilings. A test program demonstrating the feasibility of charging occupants for excess energy was required before implementation of the program throughout all military family housing units. The test metering program was established servicing approximately 10,000 family housing units to determine the feasibility and cost of installing meters in military family housing as a measure to save energy. As part of the test program, a computerized mock billing procedure was developed which includes a calculation of normal expected consumption (Norm) for each unit which could be compared with the unit's actual metered consumption. The original norm calculation procedure was developed by the Office of the Secretary of Defense (OSD) and the U.S. Army Construction Engineering Research Laboratories (CERL) and was the point of departure for Science Applications, Inc. (SAI) in this utility norm analysis task.

The objective of the Utility Norm Analysis Task was the refinement and evaluation of a procedure for calculating an energy use "norm" for predicting the energy consumption ceiling of military housing and to provide limited validation of the procedure using in-the-field testing. Throughout this study consideration was given to the implementation requirements of the norm. That is, the evaluation process had to consider tradeoffs between cost of implementation and accuracy of prediction.

The specific program objectives were to:

- Assess the completeness and viability of the "norm," as developed by OSD and CERL,
- Make modifications to improve its accuracy, as appropriate,
- Conduct field tests to determine its adequacy,
- Compare government and private housing energy consumption, and
- Determine energy consumption potential of several energy conservation improvements to that of unimproved housing units.

The approach to the overall program began with the conceptualization of the "norm" procedure and examination of approaches for its determination. The results provided a detailed blueprint of the techniques to be employed in establishing the calculational procedures and test requirements for analysis of the "norm."

The BLAST loads analysis methodology along with several other programs were reviewed to identify calculational methodologies that fulfilled the requirements of the norm concept. Performance subroutines modeling energy requirements of equipment found in the house -- such as furnaces, heat pumps, air conditioners, were prepared to provide effective energy consumption predictions from the loads analysis programs.

The impact of human factors on overall energy consumption was reviewed to allow the incorporation of the effects of family size and make up as well as time of year impacts into the norm. The incorporation of these parameters represents a significant improvement in the sophistication of residential energy consumption models.

As a result of the assessment of space conditioning and appliance utilization energy consumption prediction techniques, the "norm" calculational procedures were defined and sensitivity studies were performed over the expected range of occupancy related factors. The building space conditioning and appliance energy consumption and appropriate weighting factors were determined.

The "norm" calculational procedure was evaluated against field test data. The adequacy of the "norm" against metered energy consumption for selected housing units was assessed. The measured test data were compared with predicted energy consumption data and the cause of the discrepancies were assessed.

The degree to which the energy consumption in government and private housing varies from their respective "norms" was assessed. The norms were determined using the developed procedures for the housing units at Port Hueneme and a nearby private townhouse development. Deviations from the energy consumption norm for both housing types were evaluated.

The "norm," as developed under previous tasks, was also used to parametrically evaluate energy conservation improvements made to selected family housing units with fixed occupancy levels at three different climatic locations. The type of improvements evaluated included ceiling insulation, wall insulation, weather stripping, storm windows and doors, etc.

1.2 SUMMARY

In order to develop a norm calculational procedure, it is necessary to define what is meant by the "norm." Although a calculational technique for determining the energy consumption norm of a DOD family housing unit was already available, it was thought to be more pertinent to initially define the requirements of a norm. Once the requirements were identified they would define the kind of calculational techniques required.

Norm Approach

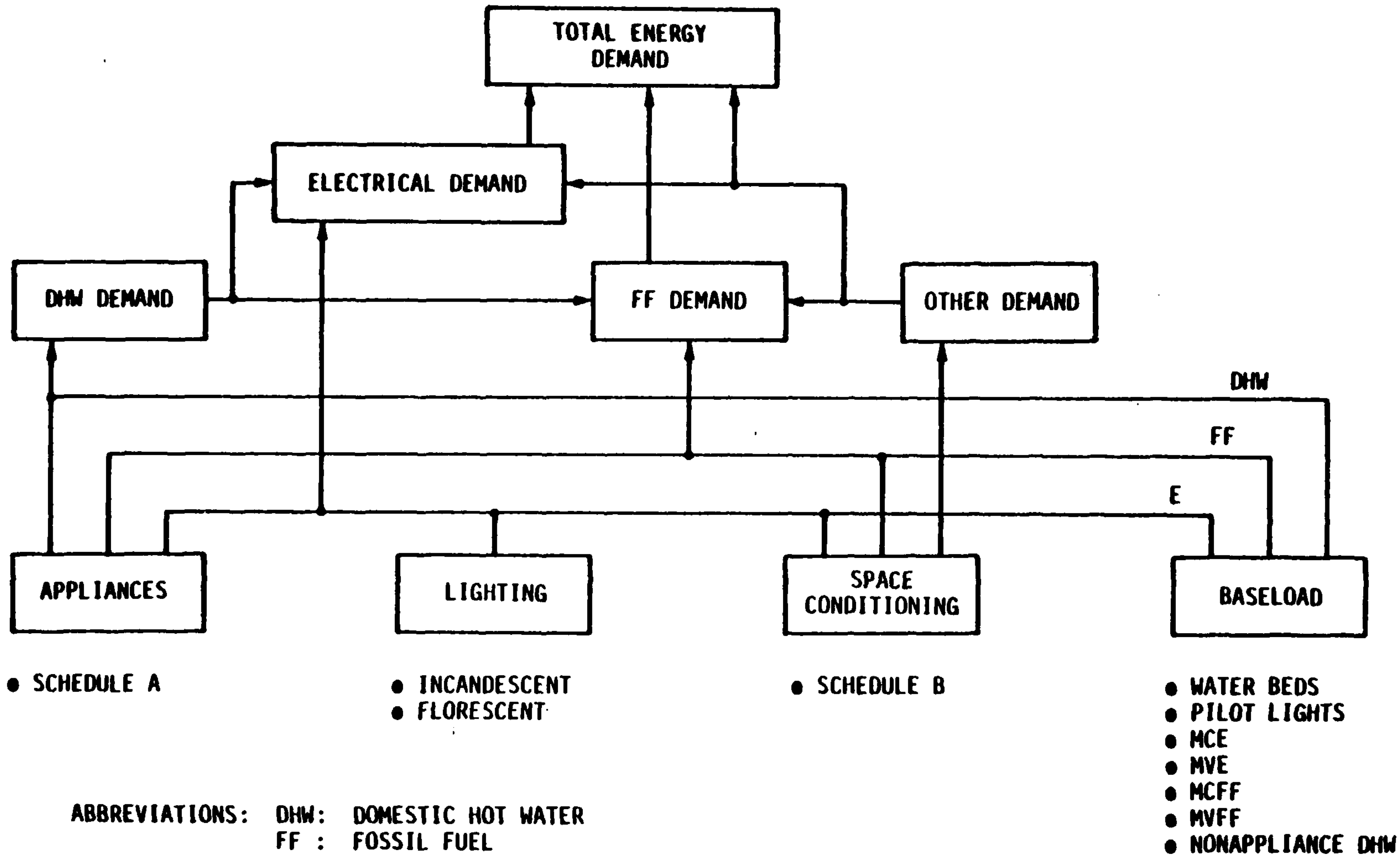
The review of the norm concept resulted in four basic principles that guided the development of appropriate algorithms. They are as follows:

1. The norm should be fair to all DOD personnel.
2. The norm should use a readily available calculation process.
3. The norm should be a relatively simple calculation process.
4. The norm should be flexible to accommodate anomalies and housing improvements.

In order to meet this guideline it was necessary to address all major components in the consumption of energy in a residence. The building block approach to the energy consumption calculations is illustrated in Figure 1.1. The energy consuming equipment is disaggregated into four major categories of sub-systems:

- o Appliances
- o Lighting
- o Space Conditioning
- o Baseload.

ENERGY DEMAND FLOWCHART



ABBREVIATIONS:
DHW: DOMESTIC HOT WATER
FF : FOSSIL FUEL
E : ELECTRICITY
MCE, MCFF: MISCELLANEOUS CONSTANT ELECTRIC, FOSSIL FUEL
MVE, MVFF: MISCELLANEOUS VARIABLE ELECTRIC, FOSSIL FUEL

Figure 1.1. Energy Demand Flow Chart

Several currently available calculation techniques which are to assess space conditioning energy consumption were reviewed to determine if they met the requirements of the norm concept.

Generically, there are six types of energy calculation methods:

- o Degree-Day Methods,
- o Equivalent Full-Load-Hour Methods,
- o Bin Methods,
- o Computer Simulations,
- o Hybrid Methods, and
- o Lifeline Billings.

From the evaluation of available techniques, it was apparent that all methods considered were not without practical, as well as theoretical, problems. However, for the norm process visualized, it appeared that some kind of simulation method would be the most appropriate choice. From the simulation methods review, the HEAP program was chosen as the basis for the norm space conditioning energy consumption methodology because of its ease of use, low cost per residential analysis, and flexibility.

The use of the modified HEAP program as the norm procedure for calculating energy consumption of the residential building was validated against a more detailed methodology and against field test data. The detailed model chosen for validation of HEAP is the BLAST computer program. The Building Loads Analysis and System Thermodynamics (BLAST) program is a comprehensive set of subprograms for predicting energy consumption in buildings. The assumption was thus made that BLAST would provide

accurate results that can be used to validate HEAP. Therefore, comparing results of BLAST and HEAP against each other would not show which code is more accurate. However, being able to obtain reasonable agreement between the two is important for the purposes of demonstrating that a less detailed and significantly faster running program can be used to simulate the building loads and therefore can be used as the norm procedure.

BLAST runs and modified HEAP runs were made for a typical townhouse in the Washington, D.C. area with approximately 1200 square feet of living area built on a slab-on-grade. The results of the analysis show two general trends. First, modified HEAP always predicted heating requirements that were less than those predicted by BLAST. Secondly, HEAP always predicted cooling requirements that were greater than those predicted by BLAST. Figure 1.2 shows a typical plot of the results for the townhouse in Washington, D.C.

To gain further confidence and feeling for the performance of the modified HEAP model, sensitivity analyses and comparisons of predictions against analyses with BLAST were performed. The first set of analyses were performed using the reference townhouse located in the Washington, D.C. area, and the results are shown in Table 1.1. The table shows the effect on the heating and cooling requirements when the respective parameter being examined is changed from some reference value, while all other parameters remain at reference conditions. The results show which parameters have the greatest impact on the heating and cooling requirements. Those parameters which most affect the heating and cooling requirements need to be determined as accurately as possible, so that the modified HEAP does not overpredict or underpredict actual requirements.

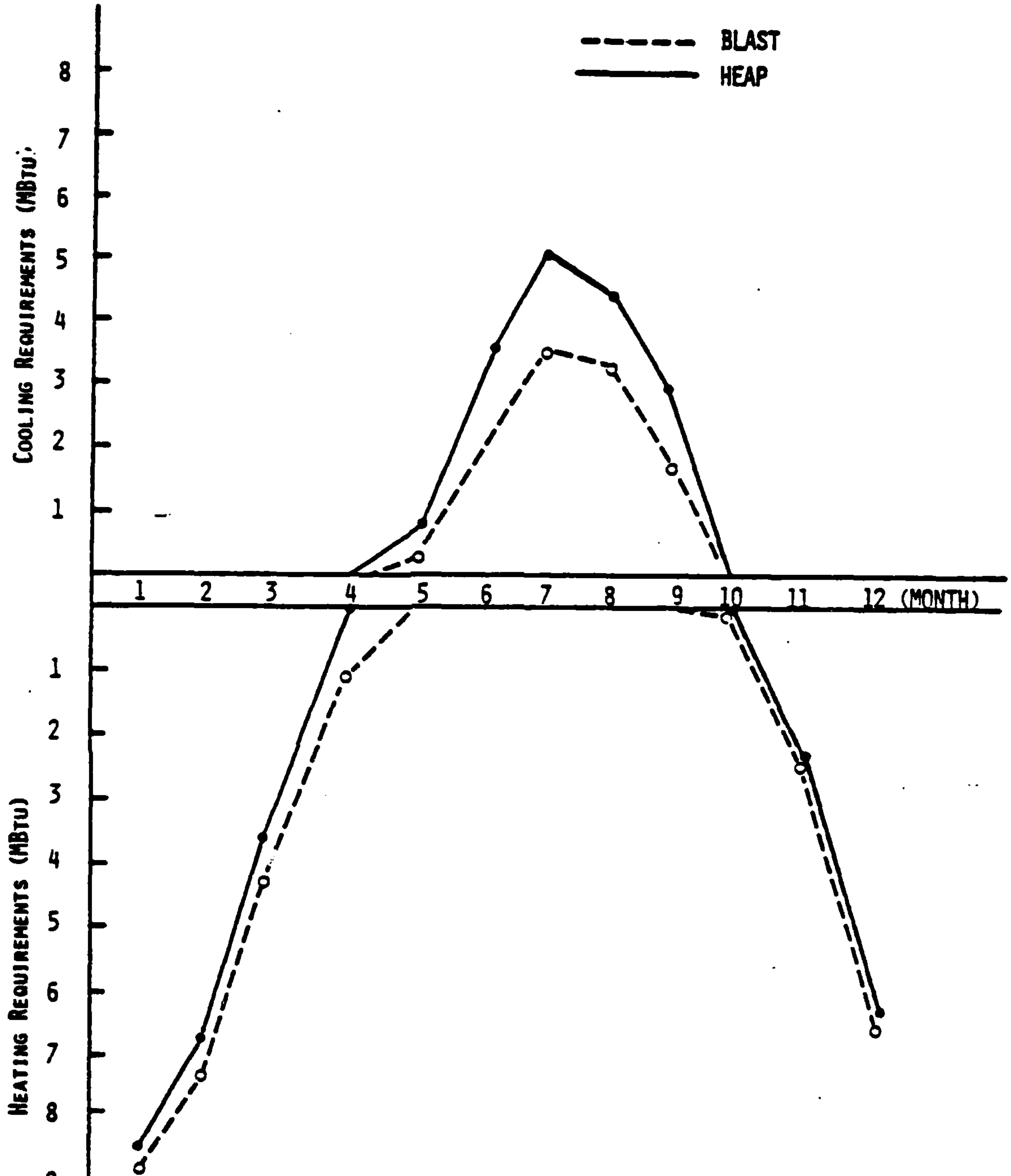


Figure 1.2. Comparison of HEAP and BLAST Monthly Heating and Cooling Requirements for a Washington, D.C. Townhouse

Table 1.1. HEAP Sensitivity Analysis Results

Parameter (reference value)	Values	% Change-Heating Req't	% Change-Cooling Req't
Wall-U Value (0.1 BTU/hr-ft^2-^{0}F)	0.05	-9.0	-7.0
	0.15	9.0	7.0
	0.20	18.0	14.0
Wall Surface Absorptivity (0.90)	0.4	2.0	-7.0
	0.7	0.8	-2.8
	1.0	-0.4	1.4
Roof Absorptivity (0.90)	0.4	1.0	-6.5
	0.7	0.4	-2.6
	1.0	-0.2	1.3
Shadow Factor (0.0) (Wall+Door+Window+Roof)	0.5	7.5	-12.0
	1.0	15.0	-24.0
Wall Shadow Factor (0.0)	0.5	1.0	-2.4
	1.0	2.0	-4.8
Roof Shadow Factor (0.0)	0.5	0.6	-3.7
	1.0	1.2	-7.4
Window Shading Coefficient (0.8)	0.0	21.0	-47.5
	0.55	6.0	-15.0
Building Air Changes/hour (.5)	1.0	11.5	0.5
	1.5	23.0	1.0
	2.0	34.5	1.5
Attic Air Changes/hour (3.0)	0	-0.5	1.5
	6	0.5	-1.0
	20	1.2	-4.0
Air Leakage Through Ducts (10%)	0	-5	-9.0
	40	15	27.0
	80	35	63
	100	45	81
Ground Reflectance (0.2)	0.4	2.75	16.0
	0.6	5.50	32.0
Thermal Time Constant (20)	10	0.51	—
	40	0.35	—

Human Factors

The evaluation of existing residential energy consumption techniques did not reveal any procedure that adequately addressed the energy consumption calculation criteria of the norm concept. Therefore the norm appliance energy consumption calculations required a completely new development. The procedures utilized to determine non-space heating energy consumption were based on an extensive evaluation of human factor considerations and usage patterns. Table 1.2 and 1.3 summarize the data that became the basis of the norm appliance utilization procedure. The HEAP procedure as developed by the National Bureau of Standards (NBS) was modified to incorporate more detailed weather data, more precise heating and cooling equipment performance modules and to incorporate the ability to use random billing periods. The combination of the modified HEAP program and the appliance utilization procedure became the norm calculational procedure.

Field Test

For the field test, the criteria for selection centered mainly on the climatic factors. It was desirable to achieve a diversity in climate among the sites chosen in order to fully test the space conditioning components of the norm calculation procedures. The chosen sites exhibit the following diverse climatic characteristics:

1. Fort Eustis, Virginia - significant space conditioning requirements in an environment near the Atlantic Ocean,
2. Great Lakes, Illinois - significant space conditioning requirements with weather strongly affected by Lake Michigan,

Table 1.2. Appliance Consumption (Kwh/day) Versus Number of Residents (Reference 31)

Electrical Appliance	Number of Residents: 1 to 2	3	4	5	6+	Correlation Factor
Range						0.848
Average Consumption	1.994	1.672	2.061	2.324	2.870	
Standard Error	0.974	0.728	0.630	0.843	1.681	
Number Metered	14	8	16	13	8	
Dishwasher						0.737
Average Consumption	0.299	0.160	0.510	0.386	0.630	
Standard Error	0.146	0.105	0.284	0.190	0.256	
Number Metered	7	2	7	10	5	
Clothes Washer						0.981
Average Consumption	0.119	0.220	0.263	0.338	0.396	
Standard Error	0.071	0.107	0.100	0.172	0.136	
Number Metered	32	23	28	26	15	
Clothes Dryer						0.916
Average Consumption	1.601	2.732	2.399	3.957	4.005	
Standard Error	1.030	1.457	0.999	2.519	2.369	
Number Metered	19	10	20	14	10	
Water Heater						0.963
Average Consumption	9.193	10.003	11.481	15.327	15.551	
Standard Error	2.657	0.057	3.093	5.670	9.897	
Number Metered	5	2	5	2	3	
Central Air						0.734
Average Consumption	7.527	9.880	10.937	12.474	10.035	
Standard Error	4.297	7.322	4.098	17.333	6.234	
Number Metered	8	8	8	12	6	
Room Air Conditioner						0.714
Average Consumption	2.623	1.656	2.442	5.806	5.813	
Standard Error	2.934	1.650	2.152	7.731	3.948	
Number Metered	13	9	11	7	2	

Table 1.3. Monthly Energy Consumption Indices for Major Appliances (From MRI Data) (Reference 31)

APPLIANCE	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
Refrigerator	1.09	1.05	1.05	1.00	.945	.91	.90	.91	.98	1.04	1.04	1.07
Freezer	1.04	1.12	1.12	1.05	.98	.93	.88	.90	.92	.99	1.03	1.05
Range	.82	.86	.91	1.03	1.11	1.18	1.24	1.20	1.05	.94	.87	.81
Clothes Washer	.87	1.00	1.04	1.08	1.00	1.00	1.00	1.00	1.04	1.04	1.04	.96
Clothes Dryer	.84	.95	.96	1.00	1.02	1.07	1.08	1.08	1.04	1.01	.97	.95
Water Heater	.85	1.05	.94	.95	1.00	1.04	1.10	1.12	1.10	1.03	.94	.85
Central Air Conditioning	3.21	2.26	1.49	.45	.12	.11	.11	.09	.12	.29	1.15	2.59
Room Air Conditioning	3.37	2.45	1.74	.53	.14	.14	.11	.07	.15	.23	.83	2.24
Cook Top	.69	.91	.96	1.07	1.15	1.08	1.16	1.16	.97	.89	1.24	.71
Separate Oven	.73	.75	.92	1.17	1.17	1.23	1.22	1.08	1.00	.98	.88	.84
Dishwasher	.88	.88	.90	.95	.97	1.05	1.02	1.10	1.07	1.12	1.02	.95

3. Fort Hood, Texas - very significant space cooling requirements in the summer, and it is in an inland environment,

4. Point Mugu, California - virtually no space conditioning requirements, and no air conditioning units are permitted on the base.

The choice of Point Mugu provided one site at which there would be no space conditioning component for the norm through the summer months of the field test program. This provided a site where the appliance portion of the norm could be validated without introducing the additional complicating factors having to do with space conditioning. Also, about half of the residences selected at Great Lakes did not have space cooling capabilities, making it possible to examine closely the effects of having or not having air conditioning among houses at the same site. A summary of participant data is presented in Table 1.4 and 1.5.

Evaluation of the field test data indicated a fairly good agreement between the actual energy consumption and the norm. The norm generally tended to under predict. Comparison of one week and four week data samples shows the following mean variances and the corresponding standard deviations between the norm and actual consumption.

	Fort Eustis	Great Lakes	Point Mugu
Four Week Period	-10.6% (16.7)	-11.0% (15.1)	-11.9% (16.8)
One Week Period	-13.1% (22.7)	-5.5% (18.4)	-10.1% (19.9)

Table 1.4. Summary of Field Test Military Housing Characteristics, Occupancy and Ages for All Four Sites

Characteristic		
Number of Units (All Sites)		40 (1)
Percent of Units with:	2 Bedrooms	30%
	3 Bedrooms	63
	4 Bedrooms	7
Total Number of Occupants in Field Test		176
Average Number of Occupants Per Unit		4.4
Average Number of Occupants Per Bedroom		1.36
Percent of Occupants in the Following Age Brackets:		
Less than 18 Years		56%
18 to 25		9
26 to 30		13
31 to 40		20
41 to 50		2
Average Age of Occupants under 18 Years		6.4

(1) Fort Eustis - 11 Units
Great Lakes - 11 Units
Fort Hood - 7 Units
Point Mugu - 11 Units

Table 1.5. Summary of Field Test Appliances for Military Field Test Units

Appliance Type and Number of Appliances in Living Unit, Where Applicable	Percent of Living Units Having Appliance (40 Units Total)
Refrigerators: 1	82
2	18
Freezer	36
Clothes Washer	90
Clothes Dryer: Gas	0
Electric	90
TV Sets: 0	2
1	67
2	24
3	7
Dishwasher	67
Microwave Oven	13
Central Air Conditioner	60
Window Air Conditioner	0

while the mean magnitudes of the percent variations were

	Fort Eustis	Great Lakes	Point Mugu
Four Week Period	16.1% (11.5)	15.8% (10.0)	14.8% (14.4)
One Week Period	22.9% (12.6)	15.3% (10.1)	16.0% (16.5)

The norm procedure generally tended to under predict energy demand with respect to the actual energy consumption recorded in the field test and the military versus private comparison. The standard deviations are reasonably small indicating that the procedure developed is feasible.

Implementation

The norm is not in the final form but is a procedure that still requires finalization. The presently identified raw data base for implementation of this norm procedure does not differ significantly from the current norm procedure except in the area of appliance data. The building characteristics are derived from the same data required for the "Group 2" analysis with the additional requirement of an on-site evaluation of orientation and shading and shadow coefficients. Weather data requires the additional determination of solar and wind data and deletion of hours above 78°F. Appliance data is required on the major energy consuming appliances and the amount of lighting in specific rooms. The approximate time required to tabulate these data, based on field test experience, was approximately 6 man hours per housing unit. This assumes that as-built drawings are available which are required to complete data acquisition.

Additional work is required to take the norm procedure and develop it fully for application to the billing program. The procedure must be expanded to allow determination of energy with steam and hot water fuel types. Actual energy consumption data is required to verify these additional portions of the procedure. Additional field data is also required for all fuel types with both heating and cooling to provide an overall assessment and identification of changes to be made to improve accuracy. Since the norm generally underpredicts actual consumption, it is expected that modifications could be made or weighting factors added to shift the predicted mean to be coincident with the mean of the measured energy consumption and allow determination of level of accuracy. This activity would take approximately a year to accomplish.

Final implementation procedures would require another year run-in time to allow assessment of building specific determination of estimated shadow factors and assumptions in the air-changeover rate calculations. A run-in period may be required for all buildings that enter the billing program. With these adjustments made the norm procedure would be ready for application in the operational billing program. The introduction of the norm procedure into the billing program including specific identification procedures for acquiring the raw residence data, development of the preprocessed data file and processing of weather data to produce the final billing norm, remains to be done. These activities could be accomplished in parallel with the final run-in assessment of the norm procedure.

Military Vs Private

An evaluation was made of the differences in energy consumption between a segment of housing at Port Hueneme and a nearby private housing segment of housing in Oxnard, CA. In a comparison of relative performance against the norm, natural gas cousumption by military residence occupants would be 22% less than for civilian occupants over the six month period studied. Relative comparison of electric consumption with respect to the norm indicated a 44% greater consumption in military residences occupants than occupants of civilian residences for the six month period. Total energy per occupant consumption comparison against the norm indicated that military occupants would consume 12% less than the civilian per occupants for the six month period.

It was found that civilian occupants in the survey were generally younger and had fewer and younger children than the military personnel as is indicated in the summary of occupancy and building data presented in Table 1.6 and 1.7. In addition, the civilian residences had fewer energy consuming appliances. As a consequence the civilian segment used less energy, especially electricity, than the military segment. However, in comparison to the norm the military sector had less variance in total energy than the civilian sector as is summarized in Table 1.8.

Energy Conservation Modifications

An evaluation was also made of the effectiveness in reducing energy consumption in typical residential buildings at Great Lakes Naval Training Center, Fort Hood Army Base and Port Hueneme Naval Base. Energy consumption analysis on three different housing units each located in a different climatic region indicate the following important conclusions:

Table 1.6. Comparison of Dwelling and Occupancy Data for Civilian and Military Dwellings

Category	OVERALL AVERAGES	
	Civilian	Military
Average Dwelling Floor Area Square Feet Per Dwelling	1065	1239
Average Number of Occupants Per Dwelling	3.9	4.4
Average Number of Occupants Per Square Foot	.036	.036
Average Number of Bedrooms Per Dwelling	2.7	3.2
Average Number of Occupants Per Bedroom	1.4	1.4

Table 1.7. Comparison of Detailed Occupancy Data for Civilian and Military Dwellings

Category	OVERALL AVERAGES	
	Civilian	Military
Percentages of		
Adults	55	51
Children	45	49
Percentages in Age Brackets		
18 to 25	19	8
23 to 30	21	3
31 to 40	7	36
41 to 50	6	5
Over 50	3	0
Average Age of Children, Years	6	10

Table 1.8. Actual Consumptions as a Percent of NORM at Oxnard and Port Hueneme, CA

	Actual Consumptions as Percent of NORM		
	Natural Gas	Electricity	Total
CIVILIAN			
Late Winter	112	109	112
Spring	158	108	147
Early Summer	107	99	105
Total	141	106	134
MILITARY			
Late Winter	85	164	94
Spring	125	148	130
Early Summer	118	140	124
Total	110	151	117

1. Replacing the single glass windows with double glass windows will result in significant reduction of heating loads.

2. Improvements in thermal characteristics of floors and attic roofs don't contribute a great deal to reduction of heating loads.

3. Improvements in air leakage will have a large effect on energy consumption and could be considered as a good portion of total energy saving.

4. Addition of R-11 or R-19 blanket insulation to exterior walls will significantly reduce the building loads but replacing R-11 with R-19 will not result in major reduction in heating loads.

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2. ANALYSIS OF THE NORM CONCEPT

The Military Construction Act of 1978 established the requirement to identify reasonable energy consumption ceiling for family housing above which occupants of military family housing would be charged for the cost of energy used. This ceiling level has been identified as the normal energy expected to be consumed by a unique set of occupants in a unique residential building. The approach to the determination of the norm was the conceptualization of the procedure and the underlying assumptions regarding its implementation. The results of this conceptualization was to provide a blueprint of the techniques to be employed in establishing the norm and the data requirements for analysis of the norm.

2.1 THE CONCEPT OF THE NORM

In order to develop a norm calculational procedure, it is necessary to define what is meant by the "norm." Although a calculational technique for determining the energy consumption norm of a DOD family housing unit was already available, it was thought to be more pertinent to define initially the requirements of a norm. Once the requirements were identified they would define the kind of calculational techniques required.

The review of the norm concept resulted in four basic principles that should guide the development of appropriate algorithms. They are as follows:

1. The norm should be fair to all DOD personnel.

The underlying thought in this principle is that no family should be penalized because of the type of housing and the type of

family living in the house. Under the fairness principle, two factors become important:

- o House characteristics and environment; and
- o the size and makeup of the family.

The characteristics of the house are the most important driving forces in determining energy requirements, since the major portion of annual energy consumption is for heating and/or cooling of the occupied space. In general, the occupants of DOD family housing do not have the option of selecting a home, and therefore, they are unable to choose an energy-efficient house. Older houses are not as energy-efficient as newer ones, although retrofitting them with added insulation, storm windows, or other conservation measures could raise their energy efficiency considerably. In addition, two identical houses can have differences of a factor of two in heating and/or cooling requirements due to micro-climatic differences and uncontrolled air leakage into the internal environment through the building envelope. Micro-climatic effects include factors such as orientation of the house with respect to true north, shading from adjacent trees and buildings, and shielding by vegetation and buildings from predominant winds. Houses generally also have cracks through which outside cold or warm air can leak into the house. This leakage, or air infiltration, causes an additional load on the furnace or air conditioning unit. The heat load imposed by air infiltration on a residential heating system may range from 30-75 percent of the total annual heating load(1).* Reducing these cracks, and therefore the infiltration, can improve the energy efficiency of a house considerably.

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*Numbers in parenthesis correspond with the list of references presented in Section 8.

Furthermore, the percentage of the total residential heat load due to air infiltration increases after traditional retrofit, since current technology to reduce the cracks is limited by both economics and technical knowledge, relative to other retrofit applications. This subject will be discussed in more detail later, but it serves to illustrate the potential impact of the principle of fairness.

The second essential factor for a fair norm is the makeup of the family; that is, the number, age, and occupation of the inhabitants have a potentially important impact on their energy requirements. Larger families require more energy for hot water, working, lighting, and other appliances -- a family with several very small children may require more hot water than a family with teenagers. The differences, as far as the requirements for the energy norm, are difficult to specify and may be neglected. This subject will be discussed in more detail later in the report.

2. The norm should use readily available or obtainable data.

This principle deals with the practical application of the norm. The computational procedure required for determining the norm for a given application should be based on data that is readily available, either from drawings, name plates, visual examination, or simple measurements. The norm should not rely on data that has to be obtained with expensive instrumentation or equipment. Thus, building characteristics should be obtainable from "as built" drawings and a cursory visual examination; equipment characteristics from the name plate ratings; and climatic variables from simple measurements. The climatic variables will be elaborated upon later in this report. Daily maximum and

minimum temperatures, total daily integrated solar radiation on a horizontal surface, and average wind speed are the minimum amount of data required.

3. The norm should be a relatively simple calculation process.

This principle also deals with the practical application of the norm. Since the norm is part of a billing process, it must be computer-oriented. In other words, the norm will be a computer program that calculates the allowable energy budget for a housing unit and compares it with the actual energy consumption. The accuracy requirement of the computed norm depends on the amount of savings desired from an implemented norm-based billing process. For example, if a household is consuming at a rate that is 35% greater than the specified norm, and if one expects a maximum savings of 25%, assuming that the family fully complies, then the accuracy of the norm prediction would have to be at least within 10% of the actual value. The question of accuracy will be dealt with in more detail in the body of this report. The calculation of the norm on the computer should be fast and not require expensive computer capabilities; however, it is presently difficult to estimate the speed at which the calculations will be performed. A cost-effectiveness study would reveal the allowable cost associated with the norm calculations; unfortunately, this is beyond the scope of the present work. All efforts should be made to minimize the computer resource requirements. The norm should be able to handle random billing periods which imposes additional complexity in calculation because every meter cannot be read on the same day. The meters will be read possibly over a period of several weeks, thus requiring a billing and norm calculation for random length periods. An additional cause for the requirement of a random billing period is the

frequent relocation of DOD personnel. The effect that this requirement has on the norm procedure will be discussed later on.

4. The norm should be flexible in order to accommodate anomalies and housing improvements.

This principle is part of the fairness requirement, and has an impact on how the norm should be structured. In this age when energy conservation measures are continuously being implemented, the energy characteristic of a housing unit can change significantly. The norm should thus be sufficiently flexible to accommodate such improvements without hardship and big expenses. The norm calculational procedure can be updated by non-technical personnel with the limited advice of energy experts. Anomalies and disputes will arise in using the norm concept as a means to allocate energy, however, it should be capable of accommodating them. These anomalies may range from vacations and long-term illnesses to poorly constructed housing units. The resolution of such items may be a purely administrative function, but could also be resolved through the norm calculation process. These are decisions to be made by DOD.

2.2 THE NORM PROCEDURE

The principles of the norm concept, discussed in the previous section, have been incorporated into a general procedure which, as yet, does not specify any algorithm for calculating the energy allowable to a housing unit. The principles are repeated here:

1. The norm should be fair to all DOD personnel.
2. The norm should use a readily available or obtainable data.

3. The norm should be a relatively simple calculation process.

4. The norm should be flexible in order to accommodate anomalies and housing improvements.

A simplified diagram of the procedure for producing a consumer's bill incorporating the norm concept is shown in Figure 2.1. Raw data describing residence and family characteristics are entered into a data base which is processed and the data fed into the energy norm calculation procedure whose results are input into the billing algorithm. The allowable energy budget is then compared with the metered consumption, and the costs are computed and provided to the consumer. The figure shows two types of raw data. The first type is collected only once and needs to be processed only once. This pre-processed data does not change except when changes are made to the housing unit, or when the characteristics of the occupants change, and therefore requires only occasional updating. The second type of raw data consists primarily of quantities which change daily and are primarily the meteorological variables of interest. This data base is very dynamic and requires continuous monitoring and updating.

A more detailed outline of the norm procedure is shown in Figure 2.2.

Three major types of data are recorded and entered into the proposed system:

- Survey data from an examination of the residence and occupants.
- Weather data from local weather stations; and
- Metered energy consumption data by residence.

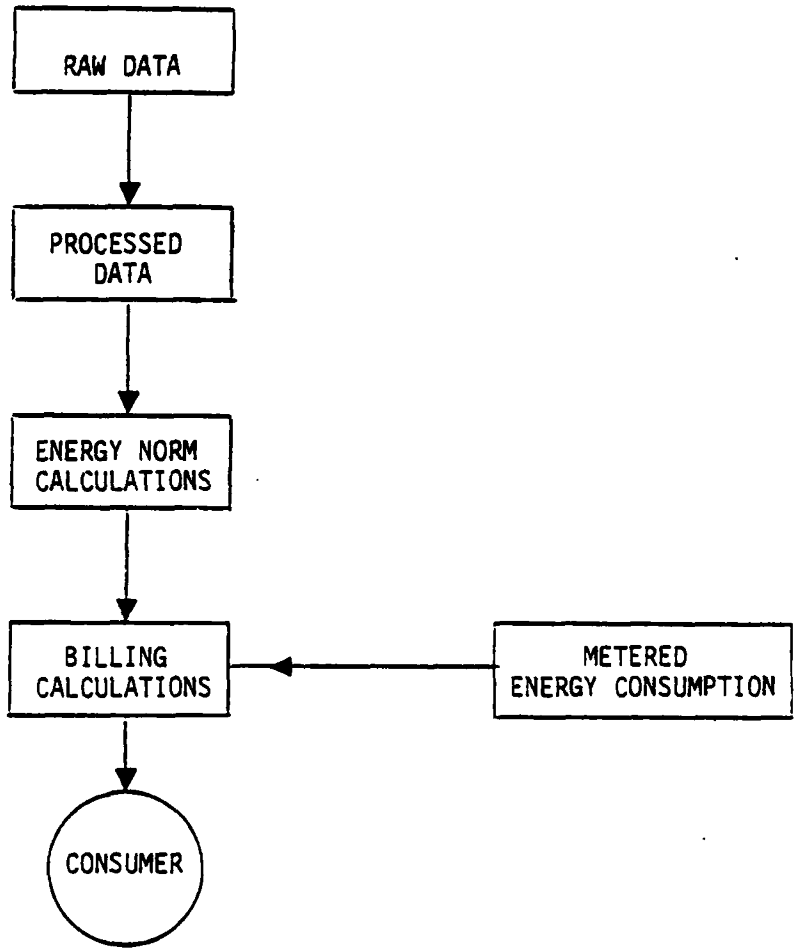


Figure 2.1. Simplified Diagram of the Norm Procedure

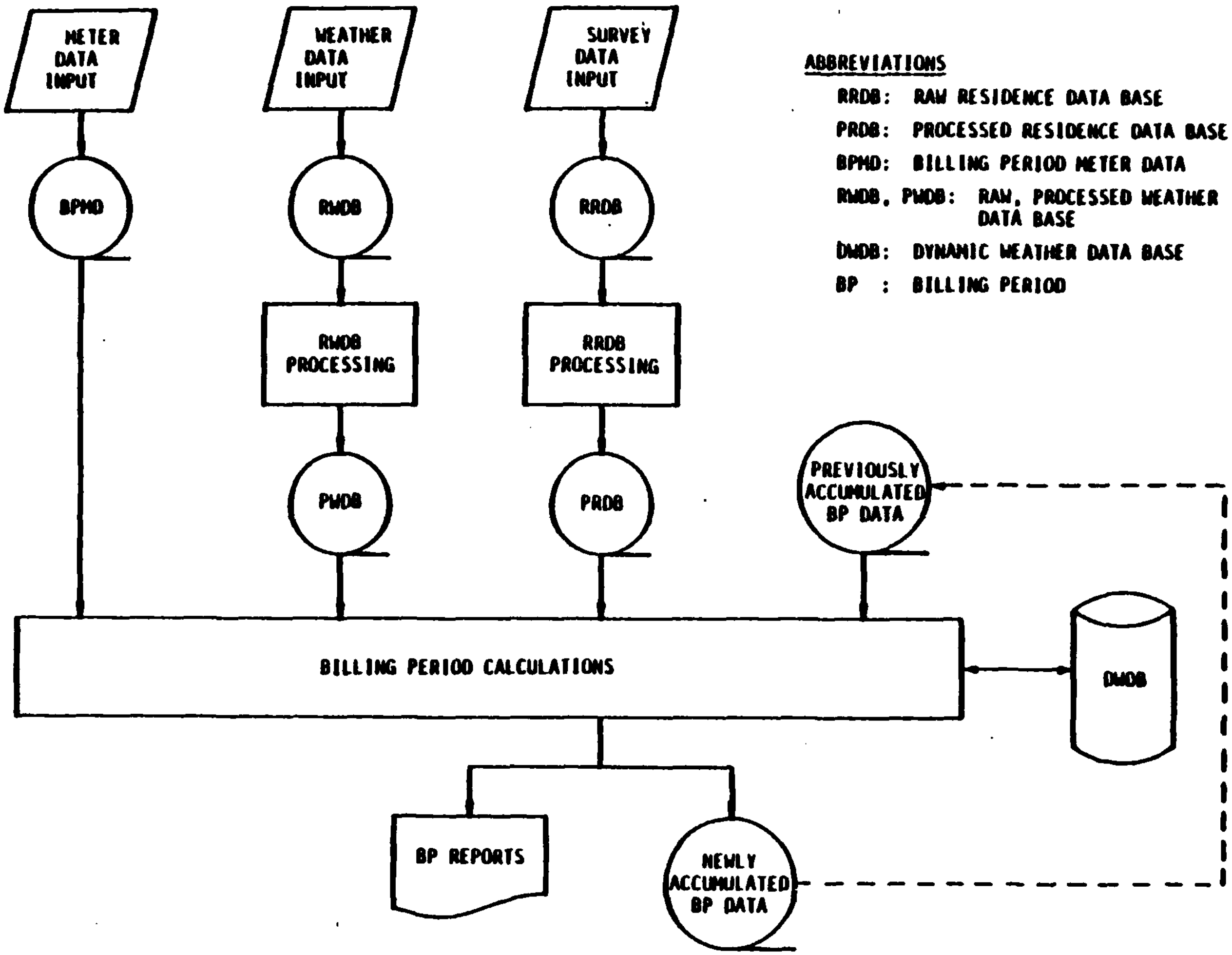


Figure 2.2. Data Processing Flow Chart

Other data bases can be incorporated in the design, e.g., equipment energy consumption characteristics by model number as provided by the DOE. Certainly expansion of the structure illustrated in Figure 2.2 is possible.

The residence survey data are entered directly into a "Raw Residence Data Base," (RRDB). Each residence would require some surveying and periodic updates would be necessary. The RRDB data are then processed into a "Processed Residence Data Base," (PRDB). The PRDB is far more extensive than the RRDB. The RRDB processing includes numerous calculations that generate fixed numbers that facilitate the billing period (BP) calculations, e.g., normal number of clothes washer cycles on a weekday in October. The concept is to prestore as many parameters as possible in PRDB, so that the BP calculations become largely table lookup and summation. The greatest departure from such a simple procedure may occur in calculating space conditioning energy consumption because of prestoring all the parameters involved, e.g., energy consumption parameterized on dry bulb temperature, relative humidity, wind velocity, and insolation level, may be inefficient. Trade-offs between prestorage and performing the calculations for each period are implicit in the approach of Figure 2.2.

The meter reading data are simply entered on a Billing Period Meter Data (BPMD) tape and used for comparison to the norm results.

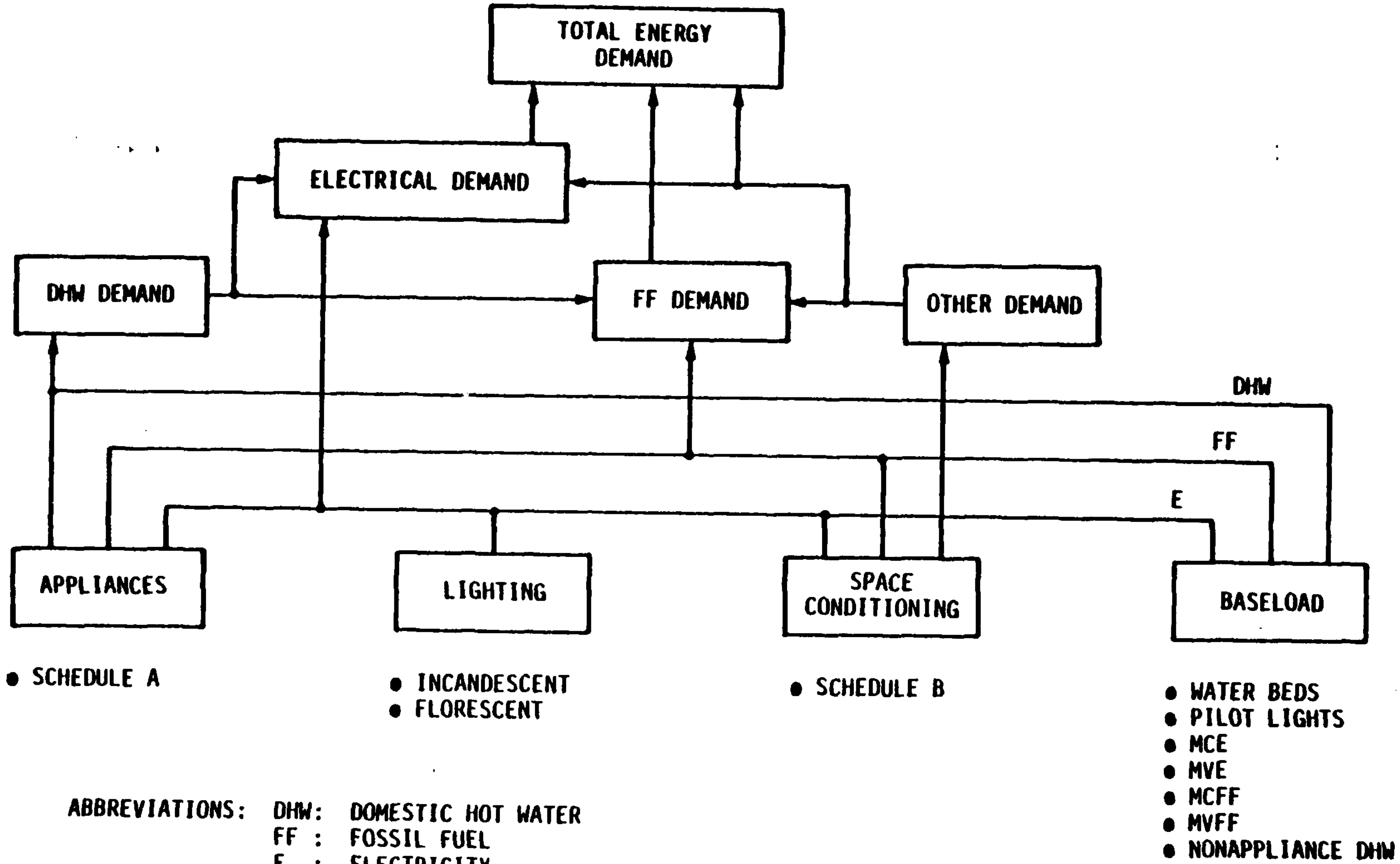
The weather data are entered in raw form and processed. The Processed Weather Data Base (PWDB) contains curve fit parameters that model the weather for each day. The data entered in the raw data base, RWDB, might very well differ from site to site, either by design or because weather stations already exist

that take sufficient data, although not necessarily in the proper form. The implication for the methodology is only that site-dependent RWDB processing software is required. The form of the PWDBs for the different sites would be identical.

The approach considered for incorporating the billing period weather data is to develop one or more "equivalent days" for the period. The data from PWDB would be combined to produce one or more types of days that in concept represent the entire period. If the billing period were 30 days long, the energy consumption resulting from the equivalent day analysis would simply be multiplied by 30 (if there were only one equivalent day). The function of the Dynamic Weather Data Base, DWDB, is to store the equivalent day data for a particular run. Thus, if two residences have identical billing period start and end dates, the analysis for the first residence would include calculations to create one or more equivalent days which would be available for the analysis of the second residence. The equivalent days are obviously solely a function of the start and stop dates for the billing period.

The building block approach to the energy consumption calculations is illustrated in Figure 2.3. The energy consuming equipment is disaggregated into four major categories of sub-systems:

- Appliances
- Lighting
- Space Conditioning
- Baseload.



ABBREVIATIONS:
DHW: DOMESTIC HOT WATER
FF : FOSSIL FUEL
E : ELECTRICITY
MCE, MCFF: MISCELLANEOUS CONSTANT ELECTRIC, FOSSIL FUEL
MVE, MVFF: MISCELLANEOUS VARIABLE ELECTRIC, FOSSIL FUEL

Figure 2.3. Energy Demand Flow Chart

The Schedules A and B referenced in Figure 2.3 are given in Figure 2.4 and 2.5, respectively.

The total energy demand is disaggregated into the following categories:

- o Electrical demand
- o Fossil fuel demand
- o Domestic hot water demand
- o Other demand, e.g., space heating from hot water or steam.

Hot water demand is carried separately throughout and is converted to electrical or fossil fuel demand only at the end. Thus hot water is treated as a primary form of energy until it is converted to metered forms of energy in the water heater model.

Other features of note in Figure 2.3 are as follows:

- o Continuous pilot lights are treated as a baseload.
- o Intermittent pilot lights are treated as part of the appliance or heater.
- o Some appliances, e.g., TVs in Schedule A (Figure 2.4), might well be moved to baseload.
- o Baseload allows constant and variable demand values. The variable values can be programmed based on some unique characteristic of the residence; they could be used as an adjustment factor in the norm calculations.
- o Showers and other nonappliance usage of hot water are incorporated as baseload.

APPLIANCES: SCHEDULE A

1. CLOTHES WASHERS
2. CLOTHES DRYERS
3. DEHUMIDIFIERS
4. DISHWASHERS
5. FREEZERS
6. HUMIDIFIERS
7. RANGES AND OVENS
8. REFRIGERATORS
9. TV

Figure 2.4. Energy Demand Flow Chart Schedule A

SPACE CONDITIONING: SCHEDULE B

COOLING

1. CENTRAL AIR CONDITIONERS (CAC)
2. ROOM AIR CONDITIONERS (RAC)

HEATING

1. FOSSIL FUEL CENTRAL FURNACE (FFCF)
2. FOSSIL FUEL ROOM UNITS (FFRF)
3. ELECTRIC RESISTANCE CENTRAL (ERC)
4. ELECTRIC RESISTANCE ROOM (ERR)
5. STEAM
6. HOT WATER

HEATING/COOLING

1. HEAT PUMP (HP)

Figure 2.5. Energy Demand Flow Chart Schedule B

Schedule B (Figure 2.5) lists the major categories of heating and cooling equipment. Extensive further subdivision will be required, particularly for any production version of the computer code. The baseload outputs to PRDB include constant and variable baseload energy consumption, the latter being specified as some function of the time of the year.

A domestic hot water (DHW) reference value based on the number and age of the occupants (NOCC, AOCC), and perhaps other variables, is also output to PRDB. The BP baseload energy consumption is determined by summing the appropriate values stored on PRDB with some processing required to average stored data if the BP start and end dates are in two different months.

Lighting poses particularly difficult estimation problems because usage varies widely and lighting energy consumption is a significant fraction of electrical energy consumption, particularly in non-electrically heated homes in the winter. Also, lighting statistics are not comprehensive and the estimates can only be as accurate as the data on which they are based. The conceptual approach establishes estimates based on the areas on the various lighted sections of the residences and the percentages of the area lighting that are incandescent and fluorescent. The calculations assume nominal output levels (lumens/ft^2) to estimate the lighting energy consumption.

Lighting is scheduled for morning and night as indicated in Figure 2.6. The peak lighting power (Watts) for morning and evening weekdays are used as reference values. The number of occupants and other factors affect the peak levels and the time of sunrise and sunset affect the estimated ON time for the days in the billing period. Thus, "equivalent" morning and evening ON times are calculated for each BP and multiplied by the prestored

values of peak power. The validity of the assumptions involved in the calculations is uncertain, which will affect the accuracy of the estimates.

MORNING

7:00 Weekday (AMMAX)

Kitchen	100%
Dining Room	100%
Bath 1	50%
Bath 2	25% x f(NOCC - 2)
Living Room	50%
Bedroom 1	50%
Bedroom 2	25% x f(NOCC - 1)
Bedroom 3	25% x f(NOCC - 2)

$$f(x) = \begin{matrix} 0 \text{ if } x \leq 0 \\ 1 \text{ if } x > 0 \end{matrix}$$

Variable Schedule:

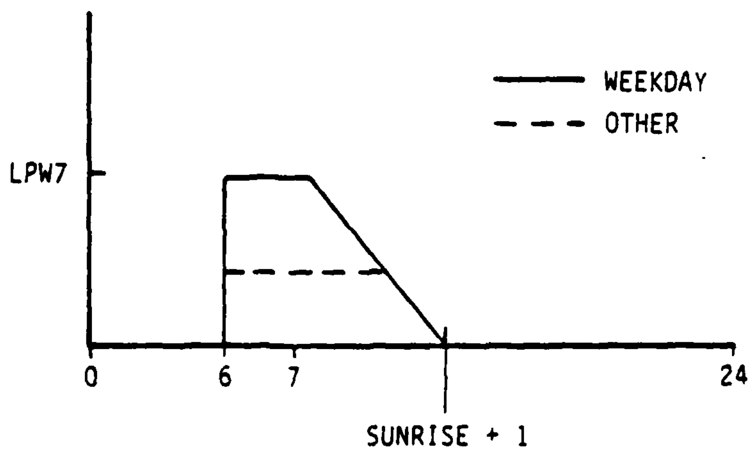


Figure 2.6. Lighting Schedules

EVENING

21:30 Weekday (PMMAX)

Living Room	100%
Dining Room	50%
Kitchen	50%
Bath 1	10%
Bath 2	10%
Bedroom 1	10%
Bedroom 2	10% x f(NOCC - 1)
Bedroom 3	30% x f(NOCC - 2)
Den	10%
Hallways	30%

$$f(x) = \begin{Bmatrix} 0 \text{ if } x \leq 0 \\ 1 \text{ if } x > 0 \end{Bmatrix}$$

Variable Schedule:

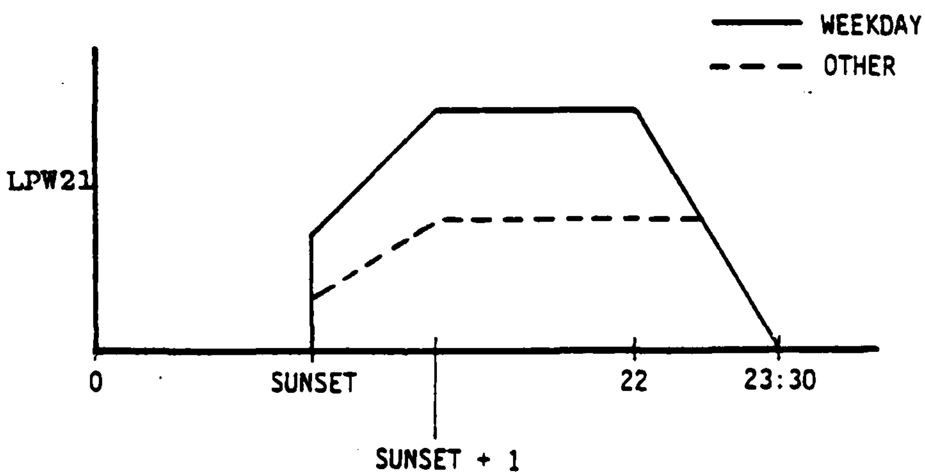


Figure 2.6. Lighting Schedules (Continued)

3. THE NORM ALGORITHM

The discussion of the considerataions underlying the development of a norm algorithm in Section 2 identified the need for a fairly rigorous procedure with regard to the space conditioning, occupancy, lighting and appliance energy requirements. The current norm as developed by CERL/OSD was used as a point of departure for a review of available norm calculational techniques. The primary emphasis was an overall review of generally available energy consumption calculational techniques, evaluation of the utility of each as a norm algorithm, and development of refined norm algorithm concepts. The result is a procedure which is applicable as a norm algorithm in a billing program and is ready for validation and analysis in the field test program.

3.1 NORM EVALUATION TECHNIQUES

In this section, various techniques are reviewed for their suitability as norm calculational techniques. The term "norm calculational technique," as used in the section, is virtually identical to the "load calculational technique" or "load model" more often encountered in heating, ventilation and air conditioning (HVAC) sizing analysis. The appliance utilization and occupancy load calculations are discussed later.

The difference between the load calculation and load model deals more with the desired end results, rather than any intrinsic differences. The norm is concerned with the determination of an <u>allowable</u> energy budget, while a load model is used to evaluate the energy <u>required</u> to satisfy certain comfort levels. Thus a load model takes into account everything that is present, while the norm accounts for only that which is allowable. The two procedures are identical when that which is

present equals that which is allowable. It is therefore natural to review load models in detail and evaluate them with respect to the four principles outlined earlier in this report.

The building industry currently has not developed a standard test procedure for evaluating its energy related calculation procedures because the prediction of energy use in a building has only recently received attention. Historically, first cost has been a primary consideration in the design of buildings. A secondary consideration for some building owners and designers has been operating cost. Implicit in the determination of operating cost is the prediction of annual energy requirements of the equipment for lighting, service water, vertical transportation, and space heating and cooling. A variety of methods have been available to calculate the design energy consumption ranging from simple procedures such as the degree-day method to hour-by-hour computerized simulations of the building's energy needs.

Since the 1973 oil embargo, operating costs (and hence the design energy consumption) have received a higher priority among owners and the building design profession. In order to determine the energy use effect of various design options, a general movement to more sophisticated calculation procedures has occurred. Resistance to this movement has also occurred due to concerns about the amount of time required to use these procedures and user capabilities with respect to using the more sophisticated approaches. Still a large variety of flexible and comprehensive methods have proliferated.

Generically, there are six types of energy calculation methods:

- Degree-Day Methods,
- Equivalent Full-Load-Hour Methods,
- Bin Methods,
- Computer Simulations,
- Hybrid Methods, and
- Lifeline Billings.

A discussion of these methods and their particular advantages, disadvantages and inherent engineering assumptions, follows.

Degree-Day Methods

The degree-day method is used to estimate seasonal heating and cooling energy consumption of buildings. Although it is recommended that its use be restricted to residences, the user must first estimate the design heat loss of the building's envelope under specified design indoor and outdoor conditions. In performing the actual calculations, the following inherent assumptions are in effect:

- The balance point, i.e. the outdoor temperature at which the daily total heating energy consumption becomes zero, is assumed to occur when the outside air temperature is $65^{\circ}F$. It is assumed that solar and internal gains offset building heat loss on a long-term, seasonal basis. However, it has been shown that residences have balance points below $65^{\circ}F$ for heating.
- The daily total energy consumption for heating and cooling a building is proportional to the mean daily outdoor temperature. Thus, over the course of a season, degree days are accumulated by subtracting the mean daily outdoor temperature from the $65^{\circ}F$ balance point.

- o Correction factors that will represent equipment oversizing and balance point shifts from 65°F are available. Recently, however, these correction factors have been shown to be incorrect.

Although these shortcomings might be reduced, the method still would have certain major restrictions. The energy effects of many time-related variables, such as solar radiation, humidity, operating profile and part load equipment performance, cannot be accounted for by the degree-day method. Furthermore, variations of ± 20 percent from actual, annual energy consumption may result from using the degree day method due to its inherent assumptions and wide variance in occupant living habits.[2]

Equivalent Full-Load-Hour-Method

The equivalent full-load-hour method is normally used to estimate residential and light commercial building cooling energy use[3], and is not applicable to heating energy analysis. This method assumes that the seasonal cooling energy consumption is proportional to the product of rated power consumption of the cooling equipment and the estimated running hours of the equipment per season. Utility data used to develop equivalent full-load-hours of operation for adequately sized cooling equipment for selected cities in the United States are available.[4] As a single measure method, it suffers the same deficiencies as the degree-day method as far as accounting for important energy-related variables. It is also highly subjective in that a single value for full-load-hours must be established from the range of values specified. It is useful for determining aggregate energy consumption of a large population of structures, but can be very inaccurate for a particular structure.

Bin Method

Both annual heating and cooling consumption for a building may be estimated by the bin method.[5] The bin method is able to account for the effect of solar radiation, humidity, wind and ambient temperature on a building's energy consumption depending on the application desired. Most bin methods consider only one independent variable: outdoor dry-bulb temperature. However, variables can often be added as desired and/or appropriate for the application.

Once the instantaneous energy consumption of a building is determined at selected outdoor temperature intervals, annual energy consumption of that building can be determined by simply multiplying it by the number of hours occurring at the specified temperature intervals. These temperature intervals are known as "bins," and are groups of temperatures, usually in increments of 5^{o}F. The seasonal energy consumption of a building is estimated from a summation of the energy requirements from each bin. To be accurate, however, the bin calculation should be performed separately for occupied and unoccupied hours, as well as for heating and cooling seasons.

Bin methods also normally assume linear heating of all load components with outdoor temperature, which is reasonably valid on an average basis, but may be inaccurate for particular billing periods.

The advantage of the method is that it is suitable for manual calculations, i.e., a computer is not required, and if computerized, the calculations are simple and computing costs are minimal. The disadvantage of the method is that it does not treat load components separately and therefore is inherently less

accurate than load component simulation models. ASHRAE has a draft bin method procedure, but it has been tested only in comparison to computer simulation methods on four buildings.

Load Component Simulation Models
Computer Simulation
Hour-by-Hour Modeling

The most complex type of calculation procedure is the computer simulation which accounts for most factors affecting building energy consumption (usually for each hour of the year) and automatically sums the hourly energy usage values to determine a building's design energy requirement. A typical hour-by-hour simulation analysis, using a digital computer, will take into consideration the dynamic interaction of building heat loss/gain due to changing weather with respect to building occupancy and performance characteristics of the HVAC equipment. This type of analysis cannot be handled by the simplified methods described above.

The main advantage in using a computer simulation is that a large number of inter-related factors can be evaluated on an hourly basis. The disadvantages of computer simulations are that they require access to a computer system, operations skill, and frequently considerable expense. Computer simulation can be done at various levels of detail, i.e., instead of hourly simulations, daily average calculations can be performed or hourly simulations for one or more typical days of the month.

Hybrid Methods

Both heating and cooling loads may be evaluated with a hybrid method. The hybrid method is generally an empirical

correlation whose coefficients are either determined experimentally or from results obtained with detailed simulations. Such methods can potentially be very accurate, but suffer from an inability to be generally applicable. Hybrid methods are applicable to a specific type of building or application. Their main advantage lies in the fact that they are very simple.

Lifeline Billing

The "lifeline" billing method is used to determine the minimum normal energy use of a residence. The procedure specifies a lifeline quantity of gas and electricity necessary to supply the minimum energy needs of the average residential user for end uses of space and water heating, lighting, cooking and food refrigeration. As implied by the word "average," this method suffers from the same drawbacks as the degree-day approach discussed above. Its advantage is, however, that the computations are simple.

3.1.1 The Degree-Day Method

The following description of this method is largely based on that given in the ASHRAE Handbook & Product Directory.(2) This method is based on consumption data which have been taken from residences in operation, and the results have been computed on a degree-day basis. While it may not be as theoretically precise as a detailed simulation procedure, the degree-day method is considered by many to be of more value for practical use.

The amount of heat required in a residence depends upon the outdoor temperature, if other variables are eliminated. Theoretically it is proportional to the difference between the

outdoor and indoor temperatures. The American Gas Association determined from records in the heating of residences that the gas consumption varied directly as the degree days, or as the difference between 65°F, and the mean outdoor temperature. In other words, on a day when the mean temperature was 20 degrees below 65°F, twice as much gas was consumed as on a day when the temperature was 10 degrees below 65°F. For any one day, when the mean temperature is less than 65°F, there are as many degree days as there are degrees difference in temperature between the mean temperature for the day and 65°F. Degree days may be calculated on other than the 65°F base, for use mainly for warehouse and other industrial spaces in which temperatures to be maintained are considerably below the 68 to 72°F range.

Studies made by the National District Heating Association of the metered steam consumption of 163 buildings located in 22 difference cities, and served with steam from a district heating company, substantiate the approximate correctness of the 65°F base chosen by the gas industry.

The number of degree days is calculated by taking the difference between 65°F and the daily mean temperature computed as half the total of the daily maximum and the daily minimum temperatures. The monthly average is obtained by adding daily degree days for each month and dividing by the number of days in the month.

Any attempt to apply the degree-day method of estimating fuel consumption for less than one month would be of very little value. This method of calculation is based on a long-term average and cannot be expected to coincide with any single year in calculating fuel requirements. Individual yearly degree-day calculations may vary as much as 20 percent above and below the long-term average.

If the degree days occurring each day are totaled for a reasonably long period, the fuel consumption during that period as compared with another period may be assumed to be in direct proportion to the number of degree days in the two periods. Consequently, for a given installation, the fuel consumption can be calculated in terms of fuel used per degree day for any sufficiently long period, and compared with similar ratios for other periods to determine the relative operating efficiencies with the outdoor temperature variable eliminated.

Such results should be used with some reservation since it is possible to have wide variations, for example, as between early and late winter periods.

The general equation for calculating the probable fuel consumption by the degree-day method is:

$$E = \frac{U\ C_D\ C_F\ D\ 24\ H_L}{\eta\ \Delta T_d} \qquad \text{[Eq. 1]}$$

where

E = fuel or energy consumption for the estimate period.

H_L = design heat loss, including infiltration, Btu per hour.

D = number of 65°F degree days for the estimate period.

t = design temperature difference, Fahrenheit.

= rated full load efficiency, decimal.

V = heating value of fuel, consistent with H_L and E.

C_D = interim correction factor for heating effect vs degree days.

C_F = interim part-load correction factor for fueled systems only; equals 1.0 for electric resistance heating.

Values of heating load, H_L, must be determined for the particular residence for which the estimate is being made. It must account for size, building materials, architectural features, use, and climatic conditions. Generally, the peak design heating load is used. Rated full-load efficiencies of fuel-fired equipment are usually in the range of 70 to 80% and may be obtained from the manufacturer. Values for C_D and C_F are given in the Handbook.

3.1.2 The Bin Method

The following description is based largely on that given in the ASHRAE Handbook & Product Directory.[5] The bin or temperature frequency occurrence method is used primarily for cooling problems, such as those dealing with air conditioners and heat pumps. In the basic version of this method, the heat gain or loss of the building is calculated and expressed as a function of ambient dry-bulb temperature, usually for occupied and unoccupied conditions. Then a count is made of the number of times each month that the average temperature for each hour of the day was within a certain range or "bin." These temperature bins are usually 5 or 10 degree increments, and are further categorized by periods of the day rather than by each hour of the day. Chapter 6 of the Air Force Manual (AFM) 88-8 is the most commonly used source for this type of temperature frequency data. Manual AFM 88-8 gives the frequency data for 5° F increments and three 8-hour daily periods. For example, a calculation is performed for 42°F outdoor (representing all occurrences of $40-44^\circ$F) and with building operation during the midnight-to-eight a.m. shift. Since there are 23 bins between -10°F and 105°F, and three shifts, 69 separate operating points would be calculated.

For many applications, the number of calculations can be reduced. A residential heat pump (heating portion), for example, could be calculated for just the bins below 65°F, and without the "three shifts" breakdown. The bin method may be used with or without refinements such as coincident wet-bulb conditions, depending on the anticipated impact of additional parameters.

3.1.3 Computer Simulation

There are many computer simulation methods available both in the open literature and in the private domain. The most prominent ones for the present purposes are DOE-2, BLAST-2, NBSLD, HEAP, and TWO ZONE. A brief discussion of each of these follows.

DOE

DOE-2 is a new public-domain computer program for the energy consumption analysis of building space conditioning systems primarily for commercial applications. Given information on the building's location, construction, operation and heating, ventilating and air-conditioning (HVAC) equipment, DOE-2 estimates the hour-by-hour energy use of a building. Its development was supported by the U.S. Department of Energy (DOE), Office of the Assistant Secretary of Conservation and Solar Application, Division of Buildings and Community Systems. Early phases of DOE-2 were also supported by the State of California Energy Resources Conservation and Development Commission (ERCDC), Division of Conservation. The major components of the program consist of four elements: the LOADS program, the SYSTEMS program, the PLANT program, and the ECONOMIC program.

The LOADS program calculates the cooling and heating loads using the algorithms described in the DOE-2 Reference and Programmer's Manual. The amount of heat entering and leaving a building is calculated for each hour of a year (8760 hrs). The heat gains and losses through walls, roofs, floors, windows and doors are each calculated separately. Heat transfer by radiation and conduction through the building skin is computed considering the effects of the thermal mass, placement of insulation, sun angle, cloud cover, and building location, orientation and architectural features. Infiltration loads are calculated based on the difference between the inside and outside weather conditions and an assumed leakage rate. Internal use of energy for lighting and equipment is also computed, according to their use, and assigned by the user for each piece of equipment that affects the energy balance of each space. The latent and sensible heat given off by the building occupants is calculated as an hour-by-hour function of the occupancy of the building.

The SYSTEMS program contains the algorithms and equations for simulating performance of the HVAC distribution systems (secondary equipment) used to control the air temperature and humidity within the building. The equations used in the SYSTEMS simulation procedure are described in the DOE-2 Reference and Programmers' Manual, as are subroutine descriptions specifying the origin of each of the algorithms used in the SYSTEMS simulation procedure.

The SYSTEMS program uses the output information from the LOADS program and a list of system characteristics (e.g., airflow rates, thermostat settings, schedules of HVAC operation, temperature setback schedules) to calculate the hour-by-hour energy requirements that the HVAC distribution system must supply to maintain the desired conditions.

The PLANT program contains the necessary equations (described in the DOE-2 Reference and Programmers' Manual) to calculate the performance of the primary energy conversion plant. The operation of each plant component (e.g., boiler, water chiller, cooling tower) is modeled based on operating conditions and part-load performance characteristics. Input information includes the type of plant equipment (e.g., two-stage absorption chiller), the size of each unit, the number of units and the schedule of equipment operation. The PLANT program uses this information and the results from the LOADS and SYSTEMS programs to calculate the energy consumption of the primary heating, cooling and ventilation equipment. Annual consumption of electricity, natural gas, oil, etc., is then placed on an output file for user examination.

The ECONOMICS program makes a life cycle cost analysis of different LOADS, SYSTEMS, and PLANT alternatives of interest to the user. It can be used to compare the costs of different building designs or to calculate savings and investment statistics for retrofits to an existing building.

The program's main advantage is that it can provide detailed and accurate information, but its disadvantage is that it is set up for commercial buildings only. The residential capability is currently being incorporated at Lawrence Berkeley Laboratory.

BLAST[6]

The BLAST (Building Load Analysis and System Thermodynamic Program) is in many ways similar to the DOE-2 program. This program was developed by the U.S. Army Construction Engineering Research Laboratory (CERL), and was written to facilitate

analysis and design of energy conservation features for existing and new military buildings, including application of liquid type active solar energy and total energy systems. Many of the methods used are based on ASHRAE algorithms. New algorithms have also been included relating to the building's shading, a cooling coil model and room heat balances. The program employs its own English-like input language and can perform two types of analyses:

- <u>Hourly Energy Analysis</u>

  Actual hourly weather data is used to calculate hourly heating and cooling loads for each zone of the building. Output from the hourly energy analysis is used as input to the system simulation subprogram.

- <u>Design Day Analysis</u>

  User-supplied input weather data is used to calculate hourly heating and cooling loads for each zone of the building for the specified design days. Output data from BLAST provides monthly and daily loads and energy consumption with separate meters for different end uses. Also both average and peak day load and energy profiles may be output.

BLAST's advantages include its high level of technical sophistication for load calculation, relatively simple input language and its availability on commercial computer time-share systems. Its disadvantages include absence of simulation capabilities for HVAC systems commonly found in small commercial buildings and residences, and lack of both extensive verification effort and documentation.

<u>NBSLD</u>

This program was developed by the National Bureau of Standards. Hour-by-hour heating/cooling requirements for a

single-zone building are computed by using detailed heat balance equations. This program has been validated on several experimental buildings such as the NBS townhouse, Twin Rivers townhouse, Houston attic ventilation test houses, and an Omaha Retirement house. The current version of the program includes heating/cooling systems such as gas-fired furnaces (with and without stack vents and with and without intermittent ignition) oil-fired furnaces (with and without stack vents) standard residential heat pumps and air conditioners. State-of-the-art procedures for evaluating the part-load characteristics of HVAC equipment are used. Other unique features of this program include daylighting calculation procedures, comfort index calculations, and whole house fan systems.

The main advantage of NBSLD is that it is a tried and proven program which, due to its easily understood program logic, has strongly influenced the development of many other public and proprietary programs since its inception. It also provides a good selection of typical residential HVAC systems. The main disadvantages are computer cost and resource, and the complexity of the input.

HEAP

The HEAP (Home Energy Audit Program) was also developed by the National Bureau of Standards (NBS) for use by energy officials in evaluating various energy audit procedures. This program uses monthly normal weather data to evaluate the energy saving potential of using solar heating and cooling and insulating hot water tanks, duct work, and hot water pipes. The thermal time constant concept is used to evaluate the time lag effect and the thermal storage effect upon building heat loss and gain. Its main advantages are ease of use and low-cost of computer time for

execution. While primarily applicable to evaluating improvements in existing dwellings, it could easily be adapted for new construction analysis. However, its validity for estimating cooling consumption has not been proven. Because of limited simulation alternatives, HEAP's main disadvantage is lack of technical sophistication when compared with DOE-2 or BLAST.

TWO ZONE[7]

Developed by the Lawrence Berkeley Laboratory, this program computes the hourly heating and cooling load for the north and south zones ("two-zones") of a single-family dwelling and provides for thermal coupling between them through convective air exchange. Program input consists of hourly weather data, internal loads, schedules for active controls, and calculated thermal transfer functions. Output from the simulation includes monthly summaries of heating and cooling loads. HVAC equipment simulation is limited to an evaporative cooler and a warm air furnace with a fixed efficiency. No active solar systems are simulated by TWO ZONE. A special feature of this program is its ability to analyze the scheduled opening and closing of shades and curtains and to evaluate the benefit of natural ventilation by window openings.

The advantages of TWO ZONE are its simplicity, cost of use, and its ability to assess natural cooling. Its disadvantage is its limited scope relative to thermal load and HVAC system types.

3.1.4 Hybrid Methods

Hybrid methods are basically energy consumption correlations based either on experimental or computer generated data. Two such methods will be discussed here -- the BLAST NORM and the IBM MODEL.

THE BLAST NORM

The BLAST NORM is a procedure developed by the U.S. Army Construction Engineering Research Laboratory specifically for the purposes of the Mock Billing Program discussed earlier in Section 2. The procedure is a simple correlation of detailed analyses performed with the BLAST computer program. Because of its importance, a detailed description of this algorithm will be given here. The calculation of the energy norm is performed in 9 steps, as follows:

STEP 1. Calculation of non-heating and cooling electrical consumption (E). The energy norm for electrical consumption can be expressed as:

$$E = \sum_{i=1}^{12} N_i \ E_i \qquad \text{[Eq. 2]}$$

Where:

N_i = Number of days in billing period which fall in the i^{th} month (i.e., i = 1 = Jan, i = 2 = Feb)

E_i = Daily DOD specified electrical energy consumption (Kwh) for other than heating and cooling for the i^{th} month. The values for E_i are given in Table 3.1 and depend on the number of bedrooms in the housing unit.

STEP 2. Calculate energy to run gas (P_G) and oil (P_O) pilot lights.

$$PG = N \cdot PDG \qquad \text{[Eq. 3]}$$

$$PO = N \cdot PDO \qquad \text{[Eq. 4]}$$

Where:

$$N = \sum_{i=1}^{12} N_i \qquad \text{[Eq. 5]}$$

Where:

N = Number of days in billing period,

PDG = Sum of daily gas consumption (Btu's) for all gas pilot lights, and

PDO = Sum of daily oil consumption (Btu's) for all oil pilot lights.

Consumption of pilot lights for individual pieces of equipment are given in Table 3.2.

STEP 3. Calculate energy consumption for domestic hot water (DWH).

$$DWH = \frac{(140^{\circ} - TWS)\ (8.34)\ (25)\ (OCC)\ (N)}{EFFDWH} \ \text{(Btu's)} \qquad \text{[Eq. 6]}$$

Where:

TWS = Average temperature of supply water for billing period ($^{\circ}F$)

OCC = Number of occupants in housing unit

N = Number of days in billing period

EFFDWH = Efficiency of hot water heater including losses from storage tank

STEP 4. Calculate energy consumption for cooking (CK).

$$CK = N \cdot CD \qquad \text{(Btu's or Kwh)} \qquad [\text{Eq. } 7]$$

CD = DOD specified allowable energy consumption for cooking (Btu's or Kwh as given in Table 3.3). CD depends on number of bedrooms and type of appliance.

STEP 5. Calculate energy consumption for heating (EH).

$$EH = \frac{(N)\ (A)\ (B3)}{EFFFUR}\ [DHDD + (B1)]\ [1 - e^{(-B2)\ (DHDD)}] \qquad [\text{Eq. } 8]$$

Where:

A,B1,B2,B3 = Constants for housing unit found from survey and BLAST runs

DHDD = HDD/N

HDD = Number of heating degree days (^{o}F) in billing period

EFFFUR = Efficiency of heating supply system

EH = Multiplied by .58 for units with heat pumps

EH = 0 if DHDD is less than or equal to B1

STEP 6. Calculate energy consumption for cooling (EC) [BTU]

$$EC = \left[\frac{(H\ R)\ (C1)}{(COP)}\right]\ [10{,}650 + (.275)(AF) + (.158)(VOL)(ACR) + (13.2)(AW)] \qquad [\text{Eq. } 9]$$

where the first term in the second square brackets compensates for internal gains, the second one represents the UA gains or losses, the third one specifies the infiltration load, while the last one determines the solar radiation gain. Furthermore:

HR = Hours of outside temperature above 78°F (Hours)

COP = Coefficient of Performance of Cooling System at full rated load

AF = Floor Area of Living Space (Ft^2)

VOL = Volume of Living Space (Ft^3)

ACR = Air Change Rate

AW = Window Area (Ft^2)

C1 = COP Part Load Adjustment Factor

STEP 7. Calculate Fan Electrical Consumption (EF).

$$EF = FH \bullet EH + FC \bullet EC \quad [Kwh] \qquad [Eq. 10]$$

Where:

FH = Fan consumption for Heating System (Kwh/Btu)

EH = Heating consumption (Btu)

FC = Fan consumption for Cooling System (Kwh/Btu)

EC = Cooling consumption (Btu)

STEP 8. Calculate other energy consumption and sum.

Elec	= Elec + EF + (N) (0 Elec)
Gas	= Gas + (N) (0 Gas)
Oil	= Oil and N (0 Oil)
Steam	= Steam + (N) (0 STM)
Hot water	= Hot water + (N) (HWR)
Chilled water	= Chilled water + (N) (CHW)

STEP 9. Calculate energy use norm.

The results of the above calculations are summed by energy type (gas, oil, electrical) and converted to the appropriate billing units (Therms, Kwh, gallons of oil, etc.).

The IBM Method

During May one of the SAI staff participated in a System Simulation and Economic Analysis (SS/EA) working group meeting sponsored by DOE's Office of Solar Applications. At this meeting IBM presented a progress report on their solar system data collection contract with DOE, and showed results of some initial work on the analysis of load data. They correlated measured heating load data with the following equation:

$$HL = K_i(T_b - T_a) + K_2 I + K_3 (T_b^i - T_b^{i-1}) + K_4 \qquad \text{[Eq. 11]}$$

where:

HL = heating load
T_b = room temperature
T_a = outside temperature
I = solar radiation

TABLE 3.1

ELECTRICAL ENERGY USE NORMS FOR LIGHTING & APPLIANCES

Month	1-2 BR (Kwh/day)	3-5 BR (Kwh/day)
January	15.77	22.52
February	17.04	24.32
March	14.97	21.42
April	15.53	22.32
May	15.13	21.65
June	15.73	22.47
July	15.32	21.97
August	15.90	21.87
September	15.97	22.80
October	15.55	22.19
November	16.13	23.03
December	15.71	22.42

TABLE 3.2

PILOT LIGHT ENERGY USE NORMS

Equipment Type	Btu/Day
Range Pilot	12,330
Hot Water Heater Pilot (Old Type)	9,600
Clothes Dryer Pilot (Old Type)	9,600
Furnace Pilot (Old Type)	20,550

TABLE 3.3

COOKING ENERGY USE NORMS

	1-2 BR	3-5 BR
Electric	2.88 Kwh/day	3.22 Kwh/day
Gas	24,000 Btu/day	27,400 Btu/day

i = superscript to denote current and previous time period

K_1, K_2, K_3, K_4 = regression constants

According to the presentor, IBM tried various schemes to fit the load data, including several based on the heating degree-day concept, but none proved as effective as the one given above. The correlation obtained was quite remarkable. This work is expected to be completed by the end of 1979. Discussion with IBM revealed that the measured loads were for an unoccupied house and that the data analyzed were for a single week only. They were confident, however, that the methodology could be extended to monthly averages.

As noted above, the equation was verified against experimental data. Such data, however, is generally not available. A comparable data set could be generated using a detailed calculations procedure such as BLAST. The hourly results computed by it could then be used as the data set for developing the coefficients K_i. The disadvantage of the IBM method is the complexity involved in running detailed computer simulations to produce the coefficients or conducting tests on a large number of residences to produce the coefficients. The advantage is that once the residences are characterized, the calculations are simple and produce accurate results for a wide range of conditions.

3.2 SELECTION CRITERIA FOR SPACE CONDITIONING ENERGY CONSUMPTION PROCEDURE

At the present time, in the United States, a considerable number of methods have been developed for evaluating the design energy requirements of a building. Although these methods fall into the six generic categories discussed above, their

capabilities vary widely, as does their ability, cost, documentation, ease of use, and other factors.[8] The criteria that are considered to be most important for the selection of an evaluation technique for the space conditioning calculations of the norm are discussed below.

Basic Energy Consumption Output

One of the basic requirements of the norm calculation technique is that it differentiate between the annual consumption of various fuel types, such as oil, gas, electricity and solar energy, for any individual building. All of the generic methods discussed above except the lifeline billing method have this capability. However, the degree-day and equivalent full-load-hours methods inherently exclude buildings which incorporate significant thermal mass and/or active solar energy systems from this estimation. The selection of either of these methods requires that a separate procedure be utilized for evaluating solar buildings. The bin method, hybrid methods, and computer simulations do not preclude estimates of renewable fuel types in the energy consumption requirements of a building. At present, the bin method has no procedure for evaluating such a building; however, computer simulations do have this capability, and hybrid methods can be made with that capability.

Flexibility for Accommodating Various Types of Building Types

The procedure should be capable of addressing in an objective manner, a wide variety of building types, particularly those commonly used for military housing. Single measure techniques such as the degree-day method cannot account for the energy effects of many common variables such as thermal mass, thermostat setting, part-load equipment performance, weather

(e.g., solar radiation, wind, humidity), shading, occupancy and lighting. These methods can account for differing equipment types by using a different, but constant, efficiency factor for each type.

Both the bin method and hybrid methods, which are multiple measuring methods, do approximate the effect of a building's thermal mass using cooling load factors, and also account to some extent for all of the other variables common to the single measure methods.

The flexibility deficiencies discussed above are not, in general, shared by computer simulations, because of the computer's inherent ability to perform a large number of calculations on many inter-related variables. The superiority in flexibility of the computer simulation to that of the other generic methods is recognized in the design profession:[8]

> "The wide ranging and constantly changing internal and external factors which determine the thermal loads on commercial and industrial buildings suggest the need for frequent evaluation of those factors to obtain reasonable accuracy in estimating annual energy consumption. The high peak internal heat loads in many commercial modern buildings make it necessary to look at these load patterns at every hour of the day and for each different type of day during the year, to evaluate the changing relationship between internal and external loads. The diversity and sophistication of modern energy distribution and control systems further contribute to energy consumption differences which can only be found by an hourly calculation of the loads on the system and the response of the system to those loads."

> "Hourly calculations do not necessarily imply that 8760 sequential computations be made. A full 8760-hour series of load and system performance calculations could be expected to give more reliable energy estimates, but such procedures require a very large computer and often considerable time for the prepara-

tion of input data. On the other hand, simpler methods such as the degree-day method or the conventional bin method may not include corsideration of the elements of energy analysis which may be essential."

Documentation

The calculation procedure should be documented to the extent that the procedures it employs can be investigated. This documentation should provide specific information regarding the source and justification for both data and algorithms used in the procedure. Additionally, this documentation should be detailed enough to permit an individual to follow the calculation through on a step-by-step basis.

The degree-day, equivalent full-load-hour and bin methods are generally documented. However, this documentation does not specify the method by which design heat loss, heating value of fuel, or design temperature are to be determined. A more detailed description of the bin method has been drafted by ASHRAE Technical Committee 4.7, Energy Calculation, but has not been released for publication at the time of this report.

Computer simulations have various levels of documentation. Generalized computer program documentation and development of mathematical procedures suitable for computer program calculations were performed by ASHRAE TC 4.7 and are publicly available.[9,10] Documentation for computer simulations developed in the private sector is generally considered to be proprietary and not available for inspection. Documentation for public-domain computer simulation is, of course, publicly available at various levels of detail depending upon the specific program.

Ease and Cost-of-Use

The calculation procedure should be as inexpensive, and simple as possible to use, commensurate with the sophistication of the building design under investigation.

The degree-day method and hybrid methods are easy-to-use and very inexpensive. Both methods can be performed by hand or with a non-programmable calculator.

The available information[11,12] concerning the bin method indicates that with training it would be more difficult to use than the degree-day and hybrid methods.

Computer simulation programs are the costliest of all calculation procedures to learn and use.[13] For example, both BLAST-2 (see Section 3.1.3 for definition) and DOE-2 require 3-4 weeks for design engineers to learn how to use, because of the nature and sophistication of these procedures. The cost of using these programs varies by building complexity. A simple residence can be input to the program and run in less than one day by a knowledgeable user.

Complete Verification

Annual energy consumption predicted by the evaluation technique should agree closely with the actual, measured performance of real buildings and/or equipment. Literature in the field (from both the public and private sector)[14,15,16] indicates that limited calculation method verification is an often strived for, and frequently obtained goal. However, much of the work that has been done in this area has been directed towards the verification of load calculation methods in computer simulations.

To DOE's knowledge, the degree-day and equivalent full-load-hour methods have not been subjected to any formal and systematic verification effort. The bin method, as drafted by ASHRAE Technical Committee 4.7[17], has been recently tested by AIA/RC against three computer programs on four different building types with encouraging results.

All of the generic calculation methods require certain assumptions which affect their verification. For example, the degree-day method and equivalent full-load hour method assume a 65°F balance point. Recently, however, this assumption has been questioned:[18,19,20,21]

> "Studies made by the American Gas Association up to 1932, and by the National District Heating Association in 1932, indicated the 65°F base. However, residential insulation practices have improved over the past 40 years from virtually none in 1930 to R-11 in walls and R-19 in ceilings today.
>
> Internal gains have also increased dramatically. Edison Electric Institute reports show average residential electric usage of 675 Kwh per month in 1973 versus 46 Kwh in 1930. Recent research indicates that monthly average internal and solar gains are sufficient to offset that a home's heat loss at mean daily temperature below 65°F."

In concluding the above discussion regarding the degree-day method, the following point was stated:[22]

> "It is important, however, to remember that the wide variations in occupant living habits and the assumptions inherent in this procedure may result in a variation of ±20% from actual fuel use on an annual basis."

Future verification efforts directed towards computer simulations are expected to be productive because computer simulations inherently offer more user control over input

assumptions as compared to other methods. Computer simulations also readily permit detailed parametric analyses to be performed. This allows the effect of one condition (for example, lighting levels or occupancy over a range of specific values) to be isolated by maintaining constant values for all other conditions. The other calculation methods do not lend themselves to this type of analysis beyond a rudimentary level.

Public-domain computer simulations, notably DOE-2 and BLAST-2, have been tested and verified on a limited basis.

Updating

The calculation procedure should be capable of being updated as the state-of-the-art in calculation methodology improves, and as innovations in technology are made.

The degree-day method and hybrid method inherently cannot be improved significantly to reflect many new building and/or HVAC system designs, because they are, by definition, single measure methods.[23]

The bin method and computer simulation can inherently be improved and updated to reflect new designs, and will continue to improve their simulation ability.

Summary and Evaluation of Selection Criteria

From the preceding discussion of the evaluation technique selection criteria, it is apparent that all methods considered are not without practical, as well as theoretical, problems. However, for the norm process visualized, it appears that some kind of simulation method would be the most appropriate

choice. From the simulation methods discussed in Section 3.1, the HEAP program was chosen as the basis for the norm space conditioning energy consumption methodology because of its ease of use, low cost per residential analysis, and flexibility.

3.3 HUMAN FACTORS AND APPLIANCE ENERGY CONSUMPTION

Determination of the Norm requires calculations for both the space conditioning systems and the remainder of the energy consuming equipment in the residence as diagrammed in Figure 2.3. The previous sections have provided background information on space conditioning load models. This section provides background data on the remainder of the energy consuming equipment, i.e. appliances and lighting, with emphasis on how human behavior affects appliance energy consumption.

The human factors data that have been gathered are summarized here to identify the criteria for estimating gas and electric requirements for residential housing units on military bases. Data are presented which are used in the norm algorithm to determine the reasonable range of energy requirements that can be expected to be consumed in a family dwelling. Varying quantities of electricity, natural gas, and fuel oil will be consumed depending upon such factors as the types and models of appliances present in the home, human factors which determine energy usage patterns, and the physical character of the home itself.

To characterize usage, two scenarios will be developed to assess residential energy requirements. One scenario will represent an all electric home in which energy usage is measured in kilowatt-hours (or Btu's). The other will assume that natural gas is used for the major household tasks of cooking, water

heating, space heating, and space cooling. These scenarios will represent a typical upper and lower limit since households use different combinations of electric and gas appliances.

The data presented estimate the typical, average or "normal" energy usage that can be expected from households of varying characteristics; each household is a unique combination of building plans, appliances, family members, and location. The data were gathered from universities and research institutes, appliance manufacturers' associations, periodicals, government agencies and public utilities, and represent a composite of information designed to determine energy use in civilian housing.

3.3.1 Typical Appliance Energy Usage

Although the operating efficiencies of major appliances have improved over the past few years and will continue to do so, many homes have older appliances which consume greater amounts of energy. Despite the growing emphasis on energy conservation, the public cannot be expected to consider energy efficiency as the major criterion in purchasing a new appliance. Typical energy usage cannot be estimated by collecting nameplate information from 1979 appliances.

Table 3.4 displays appliances that use more than 150 kilowatt-hours per year. Most of these appliances are considered major appliances with high saturation levels. Table 3.5 presents the annual natural gas usage for the major gas appliances in the United States.

For any given appliance, kilowatt-hours may be substituted for gas in therms (10^5 Btu). Conversion factors for various fuel types are presented on the following page.

Natural Gas	1.021×10^6 Btu per 1000 cubic feet
Electric Power	3,413 Btu per kwh

The conversion factors can be used to determine equivalent energy end use in terms of British Thermal Units (Btu's). However, it should be remembered that all Btu's are not equal in dollar value. The cost per Btu for natural gas is less than for electricity.

Table 3.4. Appliances Using More than 150 Kwh/Yr
(References 24, 25, 26, 27, 30, 31)

Air Cleaner	216
Air Conditioners-Central	2,000-3,6000
Room	1,275-1,3500
Blanket-Electric	147-150
Dehumidifier	377-559
Dishwasher	182-363
Clothes Dryer	840-1,397
Fans	43-291
Freezer-Frostless	1,195-2,150
Standard	700-1,450
Frying Pan	186
Heater-Portable	176
Humidifier	163-263
Lighting	1,979-2,535
Microwave Oven	190
Oven-With Range	720-1,200
Oven-Self-Cleaning	750-1,205
Refrigerator-Frostless	1,217-2,100
Standard	729-1,195
Roaster	205
TV-Black & White	120-400
Color	320-660
Water Heater	3,876-6,017

Table 3.5. Gas Consumption by Residential Appliance, 1975
(Average Consumption, Excluding Extremes)

Appliance	Average Therms Per Year (10^5 Btu)	Range (10^5 Btu)
House Range	105	90-118
Apartment Range	83	70-104
Water Heater	325	259-357
Clothes Dryer (Gas Pilot)	73	65-86
Clothes Dryer (Electric Pilot)	48	38-74
Incinerator	151	138-158
Gas Light	184	165-191
Air Conditioner Consumption/Ton	273	196-498
Gas Grill	27	21-42
Gas Heating, All Types	1,069	731-1,379

(Reference 24)

The prices in the private sector for electricity and natural gas vary from region to region, as seen in Table 3.6, which displays the lowest and highest residential bills for 250 Kwh and 500 Kwh consumptions by both geographic area and state. At the 250 Kwh level, costs ranged from a low of $2.88 in the State of Washington to $23.24 in the State of Hawaii, almost an order of magnitude difference on January 1, 1977.

In addition to the major appliances, a house may contain any number of smaller portable electric appliances. The appliances in Table 3.7 consume, on the average, less than 150 Kwh per year. If all these appliances were in a given household

Table 3.6. Lowest and Highest Residential Bills for 250 and 500 Kwh - by Geographic Division - January 1, 1977 (Reference 46)

STATE	250 Kwh Lowest Bill	250 Kwh Highest Bill	500 Kwh Lowest Bill	500 Kwh Highest Bill
NEW ENGLAND DIVISION				
Connecticut	$10.99	$17.18	$18.15	$27.37
Maine	7.00	14.45	10.20	23.90
Massachusetts	11.21	18.49	16.17	30.44
New Hampshire	12.67	15.95	20.69	24.98
Rhode Island	14.04	15.87	21.02	27.32
Vermont	10.67	19.31	16.35	26.20
MIDDLE ATLANTIC DIVISION				
New Jersey	9.98	18.46	19.05	32.56
New York	3.23	22.76	5.35	41.13
Pennsylvania	8.50	19.71	13.60	28.13
EAST NORTH CENTRAL DIVISION				
Illinois	8.84	14.67	14.50	26.63
Indiana	6.20	14.39	9.85	21.64
Michigan	7.29	14.92	9.79	24.20
Ohio	8.34	17.77	13.06	29.48
Wisconsin	5.73	13.48	10.05	20.10
WEST NORTH CENTRAL DIVISION				
Iowa	7.87	16.00	10.75	26.31
Kansas	6.15	17.30	9.40	28.05
Minnesota	5.90	18.75	9.85	33.50
Missouri	7.18	19.37	9.54	33.41
Nebraska	6.87	15.45	10.94	22.95
North Dakota	7.50	15.84	10.00	22.32
South Dakota	6.20	18.35	10.40	29.50
SOUTH ATLANTIC DIVISION				
Delaware	13.55	21.20	21.00	31.76
District of Columbia	10.21	10.21	17.45	17.45
Florida	8.80	18.12	13.80	30.15
Georgia	7.60	16.93	11.84	27.22
Maryland	10.75	16.55	17.57	27.88
North Carolina	4.50	17.88	7.00	27.05
South Carolina	9.47	16.05	14.97	24.16
Virginia	7.60	18.32	13.01	30.81
West Virginia	10.62	16.53	16.40	26.24
EAST SOUTH CENTRAL DIVISION				
Alabama	6.40	14.52	10.92	22.61
Kentucky	6.41	12.00	10.91	19.68
Mississippi	6.66	16.67	11.31	28.33
Tennessee	6.65	11.63	11.31	16.57
WEST SOUTH CENTRAL DIVISION				
Arkansas	6.25	14.53	10.50	20.51
Louisiana	6.75	16.03	11.00	26.77
Oklahoma	6.25	15.22	10.00	23.50
Texas	7.22	17.19	10.64	29.01
MOUNTAIN DIVISION				
Arizona	9.78	16.23	14.25	26.97
Colorado	6.29	16.00	9.29	25.80
Idaho	5.00	11.95	7.50	16.87
Montana	5.31	9.61	9.12	17.22
Nevada	6.85	15.72	10.05	27.82
New Mexico	8.11	18.90	11.56	27.50
Utah	5.53	13.28	8.65	17.73
Wyoming	6.94	12.87	11.22	18.33
PACIFIC DIVISION				
California	4.90	19.01	7.99	31.38
Oregon	3.40	9.45	5.40	14.91
Washington	2.88	7.93	4.68	11.83
PACIFIC-NONCONTIGUOUS				
Alaska	10.50	18.06	16.00	31.48
Hawaii	15.25	23.24	25.09	37.83

Table 3.7. Portable Electric Housewares Energy Consumption (Reference 28)

Portable Electric Housewares Energy Consumption

Product	Average operating wattage	Uses per year	Time/use (min.)	Hr/yr	Pct. actual "on" time *	kWh/yr
Baby Food Warmer	165	1092	7.3	131	100	22
Blender	300	293	0.5	3	100	0.9
Broiler	1140	100	45	75	100	85
Can Opener	100	1000	0.2	3	100	0.3
Clock	2.5	Cont.	Cont.	8760	100	22
Blanket	150	250	480	2000	50	150
Coffeemaker						138
Brew Cycle	600	600	15	150	100	90
Warm Cycle	80	600	60	600	100	48
Coffeemaker Urn						15
Brew Cycle	1200	18	30	9	100	11
Warm Cycle	100	18	120	36	100	4
Corn Popper	575	100	9	15	100	9
Curling Iron	40	300	10	50	82	1.6
Cooker-Fryer/ Dutch Oven	1200	35	60	35	54	23
Egg Cooker	550	270	5	23	100	13
Fondue/Chafing Dish	800	25	60	25	46	9
Fry Pan	1200	180	45	135	62	100
Griddle	1200	100	30	50	76	46
Hair Clipper	10	200	10	33	100	0.3
Hair Dryer - Sft. Bon.	400	100	45	75	100	30
Hair Dryer - Hard Bon.	900	100	30	50	100	45
Hair Dryer - Hand Held	600	250	10	42	100	25
Hair Setter/Curler	350	156	15	39	100	14
Heating Pad	60	52	120	104	54	3
Ice Cream Freezer	130	6	45	5	100	0.7
Ice Crusher	100	100	3	5	100	0.5
Iron	1100	52	120	104	52	60
Juicer	90	400	1	7	100	0.6
Kettle	1500	600	5	50	100	75
Knife	95	90	5	8	100	0.8
Knife Sharpener	40	52	5	4	100	0.2
Lighted Mirror	20	650	10	108	100	2
Massager-Hand Held	15	104	10	17	100	0.3
Mixer-Hand	80	150	5	13	100	1
Mixer-Stand	150	75	8	10	100	2
Roaster	1425	12	360	72	58	60
Rotisserie	1400	26	120	52	100	73
Shaver	15	365	5	30	100	0.5
Shaving Cream Dispenser	60	365	1	6	100	0.4
Slow Cooker	200	104	400	693	100	139
Table Range	1100	175	35	102	100	112
Table Clothes Washer	95	104	24	42	100	4
Toaster	1100	700	3	35	100	39
Toaster-Oven						93
(Toasting)	1500	500	3	25	100	
(Oven)	1500	280	30	140	26	
Toothbrush	1.1	Cont.	Cont.	8760	100	10
Waffle Iron/ Sandwich Grill	1200	62	30	26	80	20
Warming Tray	140	26	120	52	100	7

* Factor for the effect of on-off cycling in thermostatically controlled products
Source: Association of Home Appliance Manufacturers

and consumed their average amount of energy, 1,606.1 Kwh would be consumed per year, which is approximately the same as a refrigerator.

Many of these products do not have very high saturation levels, i.e., the percentage of homes that have purchased these products is very small. Table 3.8 gives the product saturation levels for various appliances, both major and portable. Given the saturation levels and the average Kwh usage per year, an estimate of the average energy consumption for each appliance can be calculated.

Several factors can influence household energy use; for example, one demographic factor is the number of residents in the home. Table 3.9 displays individual appliance energy consumption as a function of the number of residents. The data were gathered during a survey conducted by the Midwest Research Institute. Table 3.10 presents mathematical predictive equations developed for each appliance by performing a regression analysis of the energy consumption data of Table 3.9 as a function of number of residents.

Although it seems reasonable to assume that the addition of an individual to a household would result in increased energy consumption, this might not hold true if the incremental resident is an energy conserver and goes around turning off lights after others. The samples in Table 3.9 are relatively small for certain appliances, so the regression equations are not perfect indicators. However, given the differences that may occur due to human differences, the equations are more than adequate as a rough indicator.

Table 3.8. Product Saturation Levels for Home Appliances, 1978 (Merchandising Magazine, March 1979) (Reference 32)

Appliance	Saturation Levels
Air Conditioners	55.4%
Bag Sealers	10.6
Bed Coverings, Electric	61.8
Blenders	51.2
Calculators	98.4
Can Openers	60.7
Coffeemakers, Total	99.8
Coffeemakers, Drip-Type, Stand	31.6
Corn Poppers	43.0
Curling Irons	28.6
Digital Watches	36.7
Dishwashers	41.9
Disposers, Food Waste	42.9
Dryers, Electric & Gas	60.3
Fondues, Electric	4.6
Freezers	44.9
Frypans, Skillets	68.3
Hairdryers, Hand-Held	35.8
Hair Setters	41.8
Hamburger Makers	15.5
Hot Plates & Buffet Ranges	26.3
Ice Cream Freezers	3.1
Irons	99.9
Knives, Electric	41.7
Massagers, Hand-Held	5.1
Massagers, Shower	7.4
Microwave Ovens	7.1
Mixers, Food	92.2
Oral Hygiene Devices	14.9
Radios	99.9
Ranges, Electric, Free Standing	50.8
Ranges, Electric, Built-In	19.8
Refrigerators	99.7
Slow Cookers	34.2
Smooth-Top Ranges	1.7
Styling Combs	26.8
Television	99.9
Television, Color	85.2
Toasters	99.9
Toaster-Ovens	11.8
Trash Compactors	2.3
Vacuum Cleaners	99.9
Washers	75.2

Table 3.9. Appliance Consumption (Kwh/day) Versus Number of Residents (Reference 31)

Electrical Appliance	Number of Residents: 1 to 2	3	4	5	6+	Correlation Factor
Range						0.848
Average Consumption	1.994	1.672	2.061	2.324	2.870	
Standard Error	0.974	0.728	0.630	0.843	1.681	
Number Metered	14	8	16	13	8	
Dishwasher						0.737
Average Consumption	0.299	0.160	0.510	0.386	0.630	
Standard Error	0.146	0.105	0.284	0.190	0.256	
Number Metered	7	2	7	10	5	
Clothes Washer						0.981
Average Consumption	0.119	0.220	0.263	0.338	0.396	
Standard Error	0.071	0.107	0.100	0.172	0.136	
Number Metered	32	23	28	26	15	
Clothes Dryer						0.916
Average Consumption	1.601	2.732	2.399	3.957	4.005	
Standard Error	1.030	1.457	0.999	2.519	2.369	
Number Metered	19	10	20	14	10	
Water Heater						0.963
Average Consumption	9.193	10.003	11.481	15.327	15.551	
Standard Error	2.657	0.057	3.093	5.670	9.897	
Number Metered	5	2	5	2	3	
Central Air						0.734
Average Consumption	7.527	9.880	10.937	12.474	10.055	
Standard Error	4.297	7.322	4.098	17.333	6.234	
Number Metered	8	8	8	12	6	
Room Air Conditioner						0.714
Average Consumption	2.623	1.656	2.442	5.806	5.813	
Standard Error	2.934	1.650	2.152	7.731	3.948	
Number Metered	15	9	11	7	2	

Table 3.10. Appliance Energy Consumption as a Function of Number of Residents

Appliance	Equation	R Factor
Range	E = 1.22 + .24X	.848
Dishwasher	E = .04 + .089X	.770
Clothes Washer	E = -.0016 + .0672X	.993
Clothes Dryer	E = .526 + .603X	.920
Water Heater	E = 5.095 + 1.804X	.960
Central Air Conditioner	E = 7.11 + .765X	.671
Room Air Conditioner	E = .544 + 1.053X	.837

Appliance usage also varies from month to month. Table 3.11 displays indices indicating the relative consumption patterns from month to month for several major appliances calculated from data collected by the Midwest Research Institute[31]. Some common sense patterns of energy use are indicated in the table; for example, refrigerators, freezers and air conditioning units use more energy in the summer and less in the winter. Appliances such as furnaces, water heaters and clothes dryers, use more energy in the winter when it is cold. The appliance energy use is affected by the ambient air temperature.

Two Hypothetical Cost Scenarios are displayed in Table 3.12. In the first scenario, it is assumed that all the appliances are electric and the price of electricity is 5 cents per kilowatt-hour. The total cost per year in this case would be $1,381.50, or $115/month. In the second scenario, natural gas appliances are used wherever possible and the price of gas is assumed to be 25 cents per therm. In this case, the bill for the year would be $706.25, or $58.85 per month, 48.8% less than in an all electric home.

3.3.2 Human Factors

The impact of human variables and physical characteristics upon residential energy use has been investigated in numerous reports. Two doctoral dissertations dealing with these issues are discussed below.

In 1975, Morrison[41] conducted a survey and by use of multiple regression analysis, developed a model to determine the total amount of direct energy consumed in single family detached dwellings. The model determined that physical housing factors are more highly correlated with energy consumption than lifestyle

Table 3.11. Monthly Energy Consumption Indices for Major Appliances (From MRI Data) (Reference 31)

APPLIANCE	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
Refrigerator	1.09	1.05	1.05	1.00	.945	.91	.90	.91	.98	1.04	1.04	1.07
Freezer	1.04	1.12	1.12	1.05	.98	.93	.88	.90	.92	.99	1.03	1.05
Range	.82	.86	.91	1.03	1.11	1.18	1.24	1.20	1.05	.94	.87	.81
Clothes Washer	.87	1.00	1.04	1.08	1.00	1.00	1.00	1.00	1.04	1.04	1.04	.96
Clothes Dryer	.84	.95	.96	1.00	1.02	1.07	1.08	1.08	1.04	1.01	.97	.95
Water Heater	.85	1.05	.94	.95	1.00	1.04	1.10	1.12	1.10	1.03	.94	.85
Central Air Conditioning	3.21	2.26	1.49	.45	.12	.11	.11	.09	.12	.29	1.15	2.59
Room Air Conditioning	3.37	2.45	1.74	.53	.14	.14	.11	.07	.15	.23	.83	2.24
Cook Top	.69	.91	.96	1.07	1.15	1.08	1.16	1.16	.97	.89	1.24	.71
Separate Oven	.73	.75	.92	1.17	1.17	1.23	1.22	1.08	1.00	.98	.88	.84
Dishwasher	.88	.88	.90	.95	.97	1.05	1.02	1.10	1.07	1.12	1.02	.95
Electric Heat	.25	.22	.18	.25	.96	1.84	2.98	2.89	1.37	.54	.28	.23

Table 3.12. Hypothetical Cost Scenarios

Appliance	Scenario 1 All Electric Appliances*		Scenario 2 Electric & Gas Appliances**	
	Kwh/Yr.	Cost/Yr.	Therm/Yr.	Cost/Yr.
Range and Oven	1,200	$ 60.00	105	$ 26.25
Water Heater	5,000	250.00	325	81.25
Clothes Dryer	1,000	50.00	73	18.25
Air Conditioner	3,000	150.00	273	68.25
Heating	10,180	509.00	400	100.00
Misc. Gas	---		200	50.00
			Kwh/Yr.	
Dishwasher	25	12.50	25	12.25
Freezer	1,500	75.00	1,500	75.00
Refrigerator	1,500	75.00	1,500	75.00
Television	500	25.00	500	25.00
Misc. Electric and Lighting	3,500	175.00	3,500	175.00
Total Cost		$1,381.50		$706.25

*Cost per kwh = $.05
**Cost per therm = $.25

factors (R^2 = .573 compared with R^2 = .310). Seventeen variables were included in the multiple regression, in which 48.5% of the total variance was explained. Table 3.13 displays the variables and their perspective Beta coefficients.

The lifestyle factors in this analysis included household size, family gross income, family life-cycle stage and belief in an energy problem (three demographic variables and one attitudinal variable). The model's R^2 value is .485, indicating that there is still a great amount of variance to be explained, some of which no doubt can be contributed to other human variables.

In 1977, Hassoun[38] developed a model which explains 54% of the variation in the amount of electric energy used by the household. Appliances constitued 24% of the variance, water heaters 18%, the number of people 11%, and the employment status 1%. The predictive equation is given below.

$$Y^1 = -249 + 672X_2 + 3463X_1 + 925X_3 + 25X_4 \quad , \text{[Eq. 12]}$$

where

Y^1 = predicted electric energy usage (kilowatt-hours)
X_1 = electric water heater
X_2 = major appliances
X_3 = household size
X_4 = employment

Results of the study indicated a positive, significant relationship between energy consumed and household size, income, the number of major appliances in the home and the presence of an electric water heater. No significant relationship was found

Table 3.13. **Standardized Regression Coefficients, F-ratios, Probability of Sampling Error and Multiple Correlations of Seventeen Independent Variables on the Amount of Direct Total Energy Consumed in Single Family Detached Dwelling Units**

	Amount of Direct Total Energy Consumed		
Independent Variables	β	F	Probability of Sampling Error, One Tailed Test
Household size	.280	8.02	< .001
Major appliances	.211	3.19	< .01
Number of rooms	.173	1.30	≃ .25
Number of exterior doors	.168	2.38	< .05
Number of rooms heated	.165	1.71	< .25
Square feet	.081	.56	>> .25
Family gross income	.064	.35	>> .25
Number of floors	.055	.37	>> .25
Number of windows	.049	.24	>> .25
Insulation - floors	.027	.94	>> .25
Construction materials	.024	.73	>> .25
Family life cycle stage	.024	.58	>> .25
Number of rooms air conditioned	-.007	.56	>> .25
Belief in energy problem	-.095	1.02	> .25
Insulation - walls	-.096	1.00	> .25
Location (rural/urban)	-.127	2.14	< .05
Insulation - ceiling	-.161	3.41	> .005
Overall F		4.38	>.0001

$R = .696$ df regression 17
$R^2 = .485$ df residual 79

between the total direct electric energy used and the difference between urban and rural units, educational level, knowledge of electricity, or the number of small appliances.

The Midwest Research Institute[31] conducted a study which concluded that energy consumption per residential unit:

1. Is higher in suburban areas compared with urban areas;
2. Increased as the number of residents increases;
3. Is higher when the head of the household is between 45 and 54 years of age;
4. Decreases when the wife works fulltime;
5. Increases with family income;
6. Increases with the number of rooms in the house; and
7. Increases with the square footage of the home.

The three studies described above indicate that demographic as well as physical variables can be used as partial determinant predictors of energy consumption in residential housing units.

The Center for Environmental Studies at Princeton University, Twin Rivers, NJ[42,43,45] discovered that energy usage feedback can reduce residential energy usage and aid energy conservation. Three types of experiments were performed. In the first experiment, household energy consumption was predicted for 29 homeowners via a regression equation as a function of daily temperature. The future rate of energy usage, for each house, could be predicted based upon outdoor temperatures. Feedback was given in the form of actual energy usage compared with predicted energy usage. The effect was to reduce energy consumption 10.5%.

In the second study, respondents were asked to adopt an energy conservation goal. One group was asked to reduce energy 2%, another 20%. The group that adopted the more difficult goal was able to reduce its energy consumption 13%. The group with the less rigorous goal of 2% did not decrease their energy consumption by any appreciable amount.

In the third study, a device was placed in the residences of the homeowners which signaled them to turn off their air conditioners and open the windows when the outdoor temperature reached a comfortable level. This device, a blinking blue light in the kitchen, had the effect of reducing energy consumption 15.7%.

These three studies at Twin Rivers suggest that frequent feedback on energy usage can significantly reduce energy consumption and highlight the importance of human behavior patterns.

In a human factors experiment using cooks preparing standardized meals on kitchen ranges, Fecter(36) found that:

- More variability in energy consumption was due to the cooks than to the ranges.
- Energy consumption would be reduced significantly if cooks use ranges more efficiently (independent of the design of the range).
- The rank order of the ranges tested was the same whether design efficiency or cooks' energy use is the measure for ordering. Both are important in total kitchen range energy consumption.

A study performed in 1976 by Opinion Research Institute(37) indicated a certain degree of ignorance and misunderstanding about residential energy usage. Findings of that report indicated:

- 49% of the people set thermostats below 69°F during the day, only 4 in 10 realize that lowering the setting only one or two degrees will conserve fuel.

- 55% say they turn off the lights when they leave the room for a short time, of those that leave the lights on, 6 out of 10 believe they are saving energy.

- 77% of those people with clothes dryers run them only when fully loaded.

- 33% of the respondents know that running a fully loaded dishwasher saves energy.

Energy use has become an increasingly important issue since 1976, so the level of understanding has probably increased considerably. Historically, energy costs have been very low relative to recent cost measures.

Residents are becoming increasingly aware of energy cost increases. A survey of 100 residents in Jefferson Village and Skymeadow in New York indicates that people who have seen sharp increases in their electricity bills (in all electric homes) are organizing politically. This political organization is not, however, based upon a firm understanding of the facts[35].

Other work by Opinion Research Institute[34] involved interviews concerning people's attitudes towards energy savings. The findings indicate that perceptions of what others are willing to do to save energy is not a statistically significant factor affecting what individuals themselves are willing to do. The study indicated that if people say that they place a high degree of importance upon saving energy, they probably do. Thermostats were checked in the residences and among the people who say their families make a concerted effort to save energy, only 23% have homes heated higher than 68°F; of those who say they make little or no effort, 44% have homes heated that high.

Family effort is an important parameter. The study also indicated that approximately 3 people in 10 do not know the temperature at which their hot water control is set, and 72% of the respondents are willing to do their laundry or dishes after 9 p.m. when demand for energy is not as great as it is earlier in the day; however, only 53% think that their neighbors would be willing to do the same.

3.3.3 Lifeline Billing Methods

The Lifeline Billing method, which evolved in California, is a new procedure to determine the minimum normal energy use. The California State Legislature, at its 1975-1976 regular session, passed Assembly Bill 167 (AB167). This bill, subsequently, enacted the Miller-Warren Energy Lifeline Act, Chapter 1010.

The following is a summary of the California Public Utilities Commission hearings on preliminary considerations for the Miller-Warren Energy Lifeline Act.

This Act would direct the Public Utilities Commission (PUC) to designate a lifeline quantity of gas and electricity necessary to supply the minimum energy needs of the average residential user for end uses of space and water heating, lighting, cooking and food refrigeration.

The PUC would be directed to require electric and gas corporations to file a revised schedule of rates and charges providing a lifeline rate. The Act specifies that the lifeline rate shall not be greater than the rates in effect on January 1, 1976. It also would prohibit any increase in the lifeline rate until the average system rate in cents per kilowatt hour, or

cents per therm, increased 25 percent or more over the January 1, 1976 level.

This only applies to the Legislature's definition of "residential user," and exempts wholesale electric and gas purchases.

The PUC held hearings to establish minimum usage requirements on the affected end uses, space and water heating, lighting, cooking and refrigeration. In response to the Commission's invitation, data was filed by the following utilities:

Electric and Gas Utilities

- California - Pacific Utilities Company
- Pacific Gas and Electric Company
- San Diego Gas and Electric Company

Electric Utilities

- Bay Point Light and Power Company
- Pacific Power and Light Company
- Sierra Pacific Power Company
- Southern California Edison Company
- Southern California Water Company

Publicly Owned Electric Utility

- Sacramento Municipal Utility District

Gas Utilities

- Southern California Gas Company
- Southwest Gas Corporation

Nine liquefied petroleum gas utilities, serving small and remote communities, were included but did not supply data or appear at the hearings.

Each of the utilities represented at the hearings were asked to present their lifeline figure related to the five areas covered by the Lifeline Act, and discuss their methodologies and rationale for determining these numbers.

The Edison Company selected a family of four persons occupying a five-room dwelling, 1,000 square feet in area, as being "average."

The Commission, in keeping with a conservative construction of the terms "necessary" and "minimum," believed that Edison's concept of the "average residential user" was reasonable, and adopted it for the purpose of establishing lifeline quantities and volumes.

The data and methodologies of the responding utilities were intensely examined by the Commission. Applying this, and a certain amount of subjective consideration, the Commission submitted its figures to satisfy the Energy Lifeline Act.

Each utility was then given the opportunity to file a petition for amendment, or waiver, of the Lifeline Act quantities.

The following quantities of electricity are designated as the lifeline quantities necessary to supply the minimum energy needs of average residential users for (a) basic residential use consisting of lighting, cooking, and food refrigerating; (b) water heating; and (c) space heating:

Quantities Designated for Single Family Residences
and Metered Units of Multi-Unit Complexes

Climatic Zone No.	Climatic Zone Degree Days	Basic Residential Use Kwh/mo.	Water Heating Kwh/mo.	Space Heating Kwh/mo.
1	≤2,500	240	250	550
2	>2,500	240	250	800
3	>4,500	240	250	1,120
4	>7,000	240	250	1,420

Quantities Designated for Unmetered Units
of Multi-Unit Complexes

Climatic Zone No.	Climatic Zone Degree Days	Basic Residential Use Kwh/mo.	Water Heating Kwh/mo.	Space Heating Kwh/mo.
1	≤2,500	190	200	330
2	>2,500	190	200	480
3	>4,500	190	200	675
4	>7,500	190	200	850

The following volumes of gas, expressed in therms of heating value, are designated as the lifeline volumes necessary to supply the minimum energy needs of the average residential users for (a) cooking, (b) water heating, and (c) space heating:

Volumes Designated for Single Family Residences
And Metered Units of Multi-Unit Complexes

Climatic Zone No.	Degree Days	Cooking Therms/mo.	Water Heating Therms/mo.	Space Heating Therms/mo.
1	≤2,500	6	20	55
2	>2,500	6	20	80
3	>4,500	6	20	115
4	>7,000	6	20	140

Basic Residential Allowance: 26

Volumes Designated for Unmetered Units
Of Multi-Unit Complexes

Climatic Zone No.	Degree Days	Cooking Therms/mo.	Water Heating Therms/mo.	Space Heating Therms/mo.
1	≤2,500	5	16	33
2	>2,500	5	16	48
3	>4,500	5	16	69
4	>7,000	5	16	84

Basic Residential Allowance: 21

The three degree-day zones recognized by the California Department of Housing and Community Development and set forth in that Agency's Energy Design Manual for Residential Buildings,

supplemented by a fourth zone for areas with a degree day deficiency of more than 7,000 based on a 65°F reference temperature, were adopted as space heating zones.

Space heating quantities apply to the six months of November through April.

Rates for service for domestic lighting, heating, cooking, and water heating service supplied to multi-unit residential complexes through a master meter on a single premise with individual units submetered shall, for the lifeline blocks, be 10 percent lower than the corresponding rates for similar complexes not submetered.

Respondent electric utilities shall ascertain, by means of a declaration to be filed by each claimant of eligibility for lifeline rates, the following information:

a. Whether premises served is a single family home, includes units of a multi-family structure served through a separate meter, or includes units of a multi-family structure served through a master meter. The number of qualifying units must also be stated.

b. Whether hot water and space are provided by electricity.

c. If space heating is provided by electricity, whether the heating system is permanently installed.

3.4 APPLIANCE USAGE PROGRAM

3.4.1 General

Figure 2.3 illustrated the general approach that has been implemented for calculating billing period energy consumption for a specified residence with specified appliances and number of occupants. A computer program that performs all the calculations of Figure 2.3 except those associated with space conditioning has been developed and is labeled the Norm Appliance Usage Program, NAUP. Subroutine listings are provided in Appendix A.

The approach of Figure 2.3 is implicit in the NAUP output listings of Table 3.14. The nine appliances of Schedule A of Figure 2.4 are treated separately as indicated in Page 1 of Table 3.14, and the energy consumption calculations for each is discussed separately below. Several aspects of the general approach that merit emphasis here are as follows:

- The location of all appliances is specified as being in the:
  - Heated Space (i.e. the conditioned living space that is maintained at comfort conditions by the heating/cooling system), or in the
  - Unheated Space (e.g. garage or unconditioned basement).
- The location affects the energy consumption estimates for freezers, refrigerators and water heaters, and the internal load calculations for all appliances.
- Pilot lights for natural gas appliances are characterized as Automatic or Standing.
- Natural gas baseload energy consumption is attributed entirely to standing pilot lights.

Table 3.14. NAUP Output Listing - liance Input Data (Page 1 of 5)

```
NRES = 1025                      NLOC = 1 (FORT EUSTIS    )              4 OCCUPANTS.

                                 CAPTAIN WILLIAM FOURSOME
                                 1311 NORTH ROSENCRANS
                                 CHILDREN:  ALICE(3) & JACK(12).

                                 MILITARY HOUSEHOLD


       CLOTHES DRYER:
                          YES:  NATURAL GAS; LOCATED IN UNHEATED SPACE; STANDING  PILOT.
       CLOTHES WASHER:
                          YES:  LOCATED IN UNHEATED SPACE.
       DISHWASHER:
                          YES.
       FREEZER:
                          YES:  ENERGY CONSUMPTION =  250.0 KWH / MONTH; LOCATED IN UNHEATED SPACE.
       FURNACE:
                          NATURAL GAS WITH AN INPUT RATING OF    80000. BTU / H WITH AUTOMATIC PILOT.
       REFRIGERATORS:
                          # 1:  ENERGY CONSUMPTION =  250.0  KWH / MONTH;  LOCATED IN HEATED SPACE.
                          # 2:  ENERGY CONSUMPTION =  150.0  KWH / MONTH;  LOCATED IN UNHEATED SACE.
       RANGES & OVENS:
                          SURFACE UNITS:  NATURAL GAS; 2 AUTOMATIC PILOT LIGHTS.
                          OVENS:  ELECTRIC.
       TELEVISIONS:
                          # 1:  COLOR SET; POWER =  110.0 WATTS.
                          # 2:  B & W SET; POWER =  221.0 WATTS.
                          # 3:  B & W SET; POWER =  157.0 WATTS.
       WATER HEATER:
                          NATURAL GAS:  CAPACITY = 35.0 GAL; LOCATED IN UNHEATED SPACE;  STANDING  PILOT.
```

Table 3.14. NAUP Output Listing - Lighting Input Data (Page 2 of 5)

NRES = 1025 NLOC = 1 (FORT EUSTIS) 4 OCCUPANTS.

CAPTAIN WILLIAM FOURSOME
1311 NORTH ROSENCRANS
CHILDREN: ALICE(3) & JACK(12).

MILITARY HOUSEHOLD

		SQUARE FEET	WATTS (FLOURESCENT)	WATTS (INCANDESCENT)
KITCHEN:		70.0	300.0	127.0
LIVING ROOM:		80.0	---	250.0
BATHROOMS:	#1	15.0	---	150.0
BEDROOMS:	#1	80.0	---	400.0
	#2	75.0	---	313.0
	#3	70.0	---	293.0
	#4	65.0	---	273.0
DEN:		50.0	---	220.0
DINING ROOM:		---	---	---
HALLWAYS:		115.0	---	73.0
OUTDOOR LIGHTS:	(3.0 H / DAY)	---	---	50.0
TOTALS		620.0	300.0	2149.0

BP 16 NUM 1 (1... EU... , OCCUPANTS.

BP START: DAY #190 (MONTH # 7) BP END: DAY #222 (MONTH # 8) # DAYS IN THE BILLING PERIOD = 33

CAPTAIN WILLIAM FOURSOME

MILITARY HOUSEHOLD

	ELECTRICITY (KWH)	NATURAL GAS (CF)	WATER (GAL)
CLOTHES DRYER:	3.5	244.8	---
CLOTHES WASHER:	6.7	---	570.3
DISHWASHER:	24.5	---	519.6
FREEZER:	223.2	---	---
LIGHTING:	90.7	---	---
REFRIGERATORS:	412.0	---	---
RANGES & OVENS:			
SURFACE UNITS:	---	151.4	---
OVENS:	24.6	---	---
TELEVISIONS:	43.7	---	---
TOTALS BEFORE BASELOAD:	829.0	396.3	1089.9
BASELOAD:	46.2	1406.0	1307.0
TOTALS BEFORE WATER HEATER:	875.2	1802.2	2396.9
WATER HEATER:	---	2887.0	---
***** GRAND TOTALS ***** :	875.2	4689.3	2396.9

THE AVERAGE INTERNAL LOAD DURING THE BP: 4240. BTU / HOUR.

Table 3.14. NAUP Output Listing - Billing Period Consumption (Page 4 of 5)

NRES = 1025 NLOC = 1 (FORT EUSTIS :) 4 OCCUPANTS.

BP START: DAY #223 (MONTH # 8) BP END: DAY #252 (MONTH # 9) # DAYS IN THE BILLING PERIOD = 30

CAPTAIN WILLIAM FOURSOME

MILITARY HOUSEHOLD

	ELECTRICITY (KWH)	NATURAL GAS (CF)	WATER (GAL)
CLOTHES DRYER:	3.5	242.9	---
CLOTHES WASHER:	6.8	---	576.9
DISHWASHER:	22.4	---	475.6
FREEZER:	212.5	---	---
LIGHTING:	116.9	---	---
REFRIGERATORS:	364.0	---	---
RANGES & OVENS:			
SURFACE UNITS:	---	168.3	---
OVENS:	24.4	---	---
TELEVISIONS:	42.6	---	---
TOTALS BEFORE BASELOAD:	793.1	411.2	1052.5
BASELOAD:	44.3	1278.2	1254.4
TOTALS BEFORE WATER HEATER:	837.4	1689.3	2306.9
WATER HEATER:	---	2746.5	---
***** GRAND TOTALS ***** :	837.4	4435.8	2306.9

THE AVERAGE INTERNAL LOAD DURING THE BP: 4483. BTU / HOUR.

Table 3.14. NAUP Output Listing - Summary of Billing Period Consumption Results (Page 5 of 5)

NRES = 1025

NLOC = 1 (FORT EUSTIS)

4 OCCUPANTS.

CAPTAIN WILLIAM FOURSOME
1311 NORTH ROSENCRANS
CHILDREN: ALICE(3) & JACK(12).

MILITARY HOUSEHOLD

IDAY1	IDAY2	ELECTRICITY (KWH)	NATURAL GAS (CF)	WATER (GAL)	INTERNAL LOAD (BTU/H)
190	222	875.2	4689.3	2396.9	4240.
223	252	837.4	4435.8	2306.9	4483.

Page 2 of Table 3.14 lists the lighting input data to NAUP. The only unique feature of the lighting input is that an outdoor lighting level is specified for a fixed number of hours per day. All other lighting data are simply power levels, i.e. watts, and the lighting algorithms determine how many hours per day the lights are ON.

Pages 3 and 4 of Table 3.14 list energy consumption estimates for two separate billing periods for the same residence, and Page 5 summarizes the results of Pages 3 and 4. As indicated in Page 3, domestic hot water is accounted for throughout the calculations, and only at the end is domestic hot water converted to metered forms of energy: kWh of electricity or cubic feet of natural gas.

The example residence of Table 3.14 has an automatic dishwasher. If it did not, the water used for manual dishwashing would appear in a line labeled "Hot Water for Manual Dishwashing" immediately below the "Baseload" line. The "Dishwasher" line of data would, of course, have zero values in all columns if the residence did not have an automatic dishwasher. It is assumed in NAUP that manual dishwashing requires half as much hot water as automatic dishwashing for the same number of occupants. No definitive data have been identified that establish the hot water requirements for manual and automatic dishwashing. However, conversations with manufacturers indicate that residents are presumed to use less hot water for manual dishwashing than would be consumed by an automatic dishwasher, because people temper the hot water with cold water to avoid the discomfort of placing their hands in contact with very hot water. An incidental result is that automatic dishwashing results in superior sanitation than manual dishwashing.

The final line of output on Pages 3 and 4 of Table 3.14 is the NAUP estimate of the average internal load for the residence over the billing period. The estimate of average internal load is input manually into the heating and cooling computer code described in Section 3.5. Thus the "Space Conditioning" interface of Figure 2.3 is in reality a manual interface, and the total energy consumption estimates are determined by adding the results obtained from the NAUP and HEAP manually.

The following sections describe the calculations of the NAUP separately.

3.4.2 Baseload - Electric

Time of year scaling for baseload electricity is assumed to be identical to that for baseload water as presented in Table 3.11 with the following results:

Month	Time of Year Relative Consumption (TOYREL)
Jan	1.050
Feb	1.060
Mar	1.050
Apr	1.015
May	0.970
June	0.925
July	0.925
Aug	1.025
Sept	0.970
Oct	0.975
Nov	1.000
Dec	1.020

The scaling with occupancy is also assumed to be identical to that for baseload water as presented in Table 3.9 i.e.,

$$\text{NOCCREL} = (5.095 + 1.804\ \text{NOCC})/12.31 \qquad \text{[Eq. 13]}$$

which results in the following values:

Number of Occupants (NOCC)	NOCCREL
1	0.56
2	0.71
3	0.85
4	1.00
5	1.15
6	1.29

Table 3.15 presents the methodology that has been used to determine a nominal value of baseload electricity consumption for a family of four.

It is assumed based on Table 3.14 that a four member household consumes 535 kWh/year of electricity for miscellaneous functions. The consumption for a particular billing period and number of occupants is determined from:

$$\text{BLCE} = \text{BLCE-BASE} \times \overline{\text{TOYREL}} \times \text{NOCCREL} \qquad \text{[Eq. 14]}$$

where

BLCE-BASE = 535 x (#BP Days/365),

$\overline{\text{TOYREL}}$ = A daily average of the TOYREL values listed above, and

NOCCREL is given by the previously listed equation.

Table 3.15. Nominal Baseload Electricity Estimate for Four Occupants

Electric Baseload Appliance	Energy Consumption (Kwh/y)	Saturation Level	Baseload Contribution
Bed Coverings	150.0	61.8%	92.7
Blenders	0.9	51.2	0.5
Can Openers	0.3	60.7	0.2
Coffeemakers	138.0	99.8	138.0
Corn Poppers	9.0	43.0	3.9
Curling Irons	1.6	28.6	0.5
Fondues	9.0	4.6	0.4
Frypans, Skillets	100.0	68.3	68.3
Hair Dryers, Hand-Held	25.0	35.8	9.0
Hair Setters	14.0	41.8	5.9
Irons	60.0	99.9	60.0
Knives	0.8	41.7	0.3
Massagers, Hand-Held	0.3	5.1	0.0
Microwave Ovens	190.0	7.1	13.5
Slow Cookers	139.0	34.2	47.5
Toasters	39.0	99.9	39.0
Toaster Ovens	93.0	11.8	11.0
Toothbrushes	10.0	14.9	1.5
Subtotal			492.2
Clocks - 2 @ 22.			44.0
GRAND TOTAL			536.2
NNAUP Assumption			535.0

Notes: 1. For Energy Consumption column, cf. Table 3.7

2. For Saturation column, cf. Table 3.8

3.4.3 Baseload - Natural Gas

The entire natural gas baseload, BLCN, consists of standing pilot light energy consumption. If there are no standing pilot lights, BLCN equals zero. All standing pilot lights are assumed to be on all year long except furnace pilots. It is assumed in NAUP that furnace pilots are turned ON on Day 305 (November 1) and OFF on Day 121 (May 1). NAUP, of course, sums up furnace pilot energy consumption only for those days in the billing period for which the furnace pilot is ON. Otherwise there are no monthly or seasonal adjustments for baseload natural gas consumption.

The standing pilot power levels that are assumed in NAUP are as follows:

Appliance	Pilot Power (Btu/h)
Clothes dryer	1200
Surface unit (cooking)	150 per pilot
Oven	175 per pilot
Furnace	500 for an 80,000 Btu/h input rating furnace
Water heater	700 for a 40 gallon capacity

The furnace and water heater pilot power levels are scaled with capacity. Thus a 120,000 Btu/h furnace would be assumed to have a 750 Btu/h pilot, and a 60 gallon water heater would be assumed to have a 1050 Btu/h pilot.

3.4.4 Baseload Water

The annual average weekly hot water consumption for a family of four with a clothes washer and a dishwasher is assumed to be 550 Gal/Week. The annual average baseload hot water consumption for a family of four is determined by subtracting from the 550 Gal/Week the following:

- o Clothes washer hot water at 17 Gal/Load at 34 Load/Month; and
- o Dishwasher hot water at 15.7 Gal/Load at 8 Loads/Week.

The result is referred to as BLCH-BASE.

BLCH-BASE is adjusted for time-of-year in accordance with the following:

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	1.050
Feb	1.060
Mar	1.050
Apr	1.015
May	0.970
June	0.925
July	0.925
Aug	1.025
Sept	0.970
Oct	0.975
Nov	1.000
Dec	1.020

The above values are based on Table 3.11, for which it is assumed that half the water heater variation is caused by changes in hot water usage, and the other half is caused by different operating conditions; the latter are included in the water heater models and not in the baseload consumption models discussed here.

The variation of baseload water consumption with number of occupants is based on Table 3.9 as follows:

$$NOCCREL = (5.095 + 1.804 \times NOCC)/12.31 \qquad [Eq.\ 15]$$

which results in the following values:

Number of Occupants (NOCC)	NOCCREL
1	0.56
2	0.71
3	0.85
4	1.00
5	1.15
6	1.29

The baseload water consumption is determined from

$$\text{BLCH} = \text{BLCH-BASE} \times \overline{\text{TOYREL}} \times \text{NOCCREL} \qquad \text{[Eq. 16]}$$

where

$\overline{\text{TOYREL}}$ = Daily averaged value of TOYREL presented above;

NOCCREL = Values resulting from the equation listed above; and

BLCH-BASE = Base value of 550 Gal/Week adjusted as discussed above.

3.4.5 Clothes Dryers - All

Monthly scale factors for gas and electric clothes dryers are based on Table 3.11 with the following results:

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	1.08
Feb	1.08
Mar	1.04
Apr	1.01
May	0.97
June	0.95
July	0.84
Aug	0.95
Sept	0.96
Oct	1.00
Nov	1.02
Dec	1.07

The occupancy scale factor for both gas and electric clothes dryers is based on Table 3.11 as follows:

$$\text{NOCCREL} = (0.526 + 0.603 \times \text{NOCC})/2.938 \quad \text{[Eq. 17]}$$

which results in the following values:

Number of Occupants (NOCC)	NOCCREL
1	0.38
2	0.59
3	0.80
4	1.00
5	1.21
6	1.41

3.4.5.1 Clothes Dryers - Electric

An electric clothes dryer is assumed to consume 2.32 kWh/Load and be used an annual average of 34 Loads/Month by a family of four. The clothes dryer electricity consumption is determined from:

$$\text{CDCE} = \text{CDCE-BASE} \times \overline{\text{TOYREL}} \times \text{NOCCREL} \quad \text{[Eq. 18]}$$

where CDCE-BASE is the consumption for a family of four for the billing period number of days, and where the other factors are as noted above.

3.4.5.2 Clothes Dryers - Natural Gas

For a natural gas dryer the electricity consumption is assumed to be 0.11 kWh/Load, and the calculations are performed as described above for an electric clothes dryer.

The natural gas consumption exclusive of the pilot light is assumed to be 7.6 cubic-feet/Load at an annual average of 34 Loads/Month by a family of four. The clothes dryer natural gas consumption is determined from:

$$CDCN = CDCN\text{-}BASE \times \overline{TOYREL} \times NOCCREL \quad \text{[Eq. 19]}$$

where CDCN-BASE is the consumption for a family of four for the billing period number of days, and where the other factors are as noted above.

3.4.6 Clothes Washer

Monthly scale factors for clothes washer electricity and hot water consumption are based on Table 3.11 with the following results:

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	1.00
Feb	1.00
Mar	1.04
Apr	1.04
May	1.04
June	0.96
July	0.87
Aug	1.00
Sept	1.04
Oct	1.08
Nov	1.00
Dec	1.00

The occupancy scale factor for both electricity and hot water consumption is based on Table 3.9 as follows:

$$NOCCREL = (-0.0016 + 0.0672 \times NOCC)/0.267 \quad \text{[Eq. 20]}$$

which results in the following values:

Number of Occupants (NOCC)	NOCCREL
1	0.25
2	0.50
3	0.75
4	1.00
5	1.25
6	1.50

Clothes washer consumption is assumed to be 0.20 kWh/Load and 17.0 Gal/Load, and a family of four is assumed to wash an annual average of 34 Loads/Month. Clothes washer consumptions for a billing period are determined from:

$$CWCE = CWCE\text{-}BASE \times \overline{TOYREL} \times NOCCREL \qquad [Eq.\ 21]$$

and

$$CWCH = CWCH\text{-}BASE \times \overline{TOYREL} \times NOCCREL, \qquad [Eq.\ 22]$$

which are expressions for electricity and hot water consumption respectively. The BASE values are determined for a family of four for the number of billing period days in accordance with the assumptions noted above.

3.4.7 Automatic Dishwashers and Manual Dishwashing

Monthly scale factors for dishwasher electricity and hot water consumption are based on Table 3.11 with the following results:

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	1.02
Feb	1.10
Mar	1.07
Apr	1.12
May	1.02
June	0.95
July	0.88
Aug	0.88
Sept	0.90
Oct	0.95
Nov	0.95
Dec	1.05

The occupancy scale factor for both electricity and hot water consumption is based on Table 3.9 as follows:

$$\text{NOCCREL} = (0.04 + 0.089 \times \text{NOCC})/0.396 \qquad [\text{Eq. } 23]$$

which results in the following values:

Number of Occupants (NOCC)	NOCCREL
1	0.33
2	0.55
3	0.78
4	1.00
5	1.23
6	1.45

Dishwasher electricity and hot water consumption are assumed to be 0.74 kWh/Load and 15.7 Gal/Load respectively, and a family of four is assumed to wash an annual average of 8 Loads/Week. Dishwasher consumptions for a billing period are determined from:

$$\text{ADWCE} = \text{ADWCE-BASE} \times \overline{\text{TOYREL}} \times \text{NOCCREL} \qquad [\text{Eq. } 24]$$

and

$$ADWCH = ADWCH\text{-}BASE \times \overline{TOYREL} \times NOCCREL \quad [Eq.\ 25]$$

which are expressions for electricity and hot water consumption respectively. The BASE values are determined for a family of four for the number of billing period days in accordance with the assumptions noted above.

The hot water consumption for manual dishwashing is determined as:

$$MDWCH = ADWCH/2. \quad [Eq.\ 26]$$

i.e., as half the consumption that would occur if the residence had an automatic dishwasher.

3.4.8 Freezers

Monthly scale factors for food freezer electricity consumption are based on Table 3.11 with the following results:

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	0.88
Feb	0.90
Mar	0.92
Apr	0.99
May	1.03
June	1.05
July	1.04
Aug	1.12
Sept	1.12
Oct	1.05
Nov	0.98
Dec	0.93

The variations above are implicity assumed to be caused by lower household heated space temperatures in winter than in summer.

There is no occupancy factor assigned to food freezers. Freezer electricity consumption is determined from

$$FRCE = USFAC \times FRCE\text{-}BASE \times \overline{TOYREL} \qquad [Eq.\ 27]$$

where

$FRCE\text{-}BASE$ = An input value in kWh/month (cf. Page 1 of Table 3.14) scaled to the number of billing period days;

$\overline{TOYREL}$ = Daily averaged TOYREL over the billing period; and

USFAC = 1 if the freezer is located in the heated space; and

= TIUSAV/75 if the freezer is located in the unheated space.

TIUSAV is the average temperature of the unheated space over the billing period and is determined by averaging the outdoor and heated space temperatures each day of the billing period. The daily value of the unheated space temperature is thus assumed to be

$$TIUS = (TIDB + TODB)/2, \qquad [Eq.\ 28]$$

where TIDB and TODB are the indoor and outdoor dry-bulb temperatures for the day, and

$$TIUSAV = \overline{TIUS},$$

i.e., the average of the unheated space temperatures for the billing period.

TODB is determined in Subroutine WERMS by reading the maximum and minimum outdoor temperatures for the day and averaging the two.

TIDB is assumed to vary throughout the year as follows:

Month	TIDB (^{o}F)
Jan	70
Feb	70
Mar	72
Apr	74
May	76
June	78
July	80
Aug	80
Sept	78
Oct	76
Nov	74
Dec	72

The expression for USFAC implicitly assumes that the freezer inside temperature is 0^{o}F, for which it is apparent that the numerator is the actual temperature difference from inside to outside, and the denominator is the nominal temperature difference from inside to outside, i.e. 75 minus zero or 75^{o}F.

3.4.9 Lighting

Lighting input data are in the form of total watts per room as indicated in Table 3.14, Page 2. NAUP performs three calculations of lighting consumption, and sums the results. The three categories are:

- o A.M. Lighting,
- o P.M. Lighting, and
- o Outdoor Lighting

The outdoor lighting energy consumption is determined from the input number of ON hours per day and the number of watts of outdoor lighting. A.M. and P.M. calculations are somewhat more complex. Table 3.16 lists the "maximum coincident percentage of watts ON" in the A.M. and P.M. by number of occupants and number of bedrooms and bathrooms. The percentages and terminology are intended to determine maximum A.M. and P.M. "watts ON" during a high activity period. The maximum values are labeled AMWMAX and PMWMAX for the A.M. and P.M. respectively.

AMWMAX and PMWMAX are determined simply by multiplying the factors of Table 3.16 times the input wattages of Page 2 of Figure 3.14 and summing.

A.M. Lighting Electricity Consumption

The A.M. lighting profile assumed by NAUP is illustrated in Figure 3.1. The lights are turned ON to AMWMAX at 6:30 A.M. if sunrise occurs after 5:30 A.M. At sunrise time plus one hour the lighting level starts to be reduced, and is reduced to zero at sunrise time plus two hours. If sunrise occurs prior to 5:30 A.M., the lighting still comes on at 6:30 A.M. but at a lower level as indicated in Figure 3.1. Sunrise and sunset times are averaged over the billing period for the location of interest, for purposes of the A.M. and P.M. lighting calculations.

The profiles of Figure 3.1 are integrated in NAUP to determine A.M. Watt-Hours per day. The result is multiplied by the number of days to determine the total A.M. lighting electricity consumption for the billing period.

Table 3.16. Lighting Maximum Coincident Percentage of Watts On in AM and PM

TIME OF DAY	AM					PM				
NOCC	1+	3+	5+	7+	9+	1+	3+	5+	7+	9+
Kitchen	100%	100%	100%	100%	100%	50%	50%	50%	50%	50%
Living Room	50	50	50	50	50	100	100	100	100	100
Bath 1	50	50	50	50	50	20	20	20	20	20
Bath 2	---	50	50	50	50	---	20	20	20	20
Bath 3	---	---	50	50	50	---	---	20	20	20
Bedroom 1	50	50	50	50	50	20	20	20	20	20
Bedroom 2	---	50	50	50	50	---	20	20	20	20
Bedroom 3	---	---	50	50	50	---	---	20	20	20
Bedroom 4	---	---	---	50	50	---	---	---	20	20
Bedroom 5	---	---	---	---	50	---	---	---	---	20
Den	---	---	---	---	---	10	10	10	10	10
Dining Room	100	100	100	100	100	50	50	50	50	50
Hallways	30	30	30	30	30	30	30	30	30	30

P.M. Lighting Electricity Consumption

The P.M. lighting electricity consumption is calculated in the same manner as A.M. lighting electricity consumption except the profile of Figure 3.2 is used, and the maximum value is PMWMAX, not AMWMAX as in Figure 3.1. P.M. lighting starts to come on one hour before sunset, is fully on at sunset, stays fully on until 10:00 P.M., and is fully off at 11:30 P.M. The profile of Figure 3.2 is integrated to determine daily P.M. consumption and multiplied by the number of billing period days to determine total P.M. lighting electricity consumption for the billing period.

3.4.10 Refrigerators

Monthly scale factors for refrigerator electricity consumption are based on Table 3.11 with the following results.

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	0.90
Feb	0.91
Mar	0.98
Apr	1.04
May	1.04
June	1.07
July	1.09
Aug	1.05
Sept	1.05
Oct	1.00
Nov	0.94
Dec	0.91

The variations above are implicitly assumed to be caused by lower household heated space temperatures in winter than in summer.

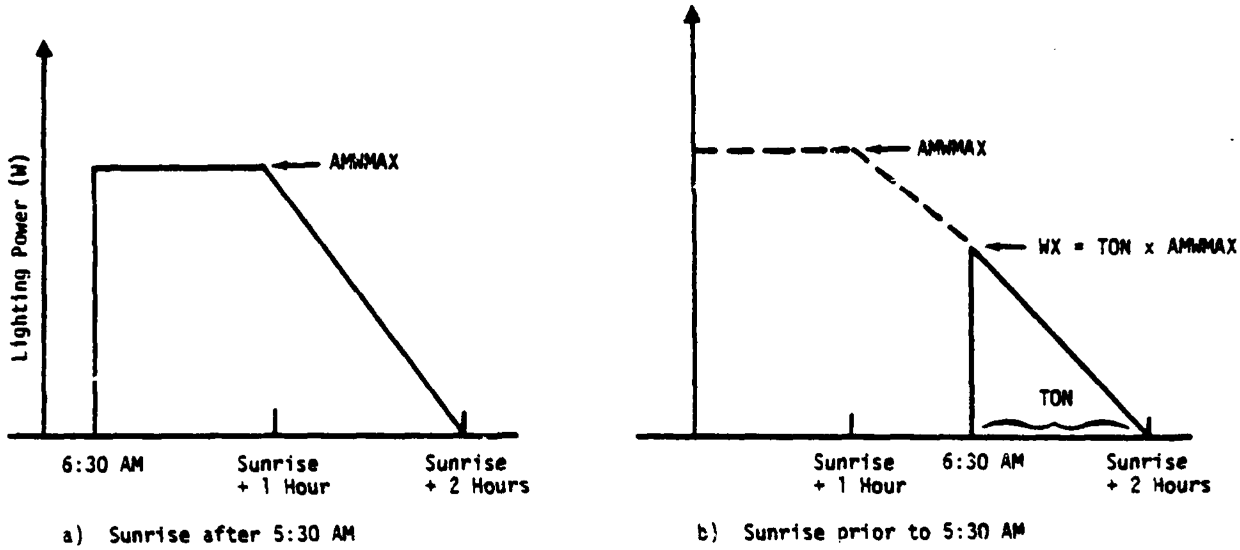


Figure 3.1. AM Lighting Profile

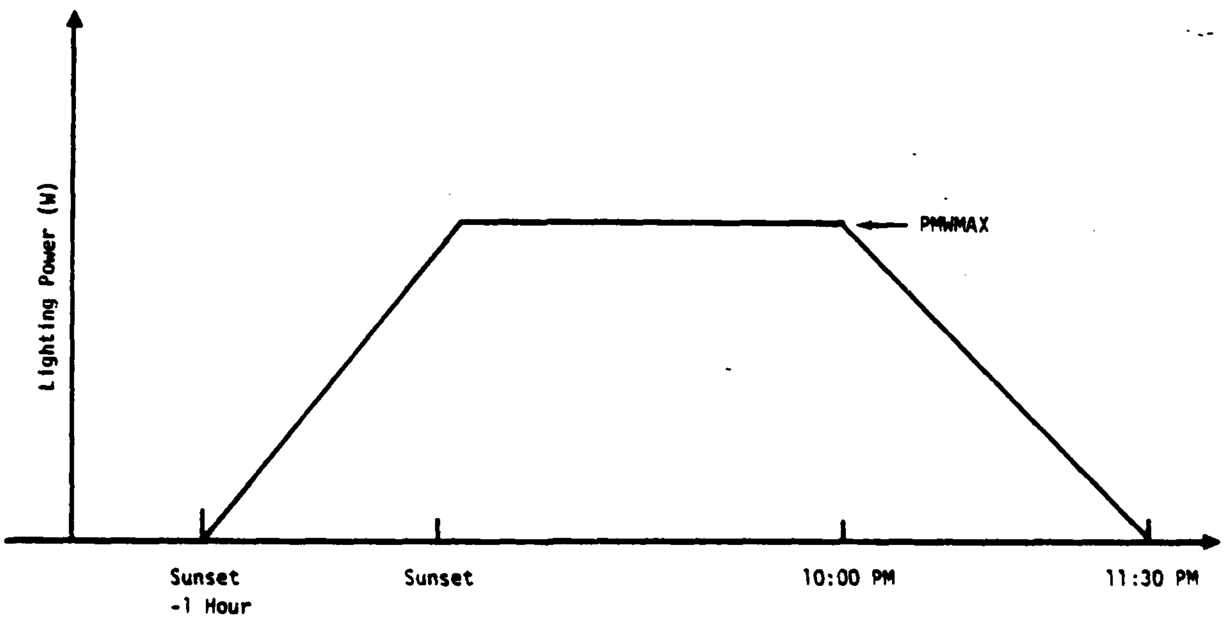


Figure 3.2. PM Lighting Profile

There is no occupancy factor assigned to refrigerators.

Refrigerator electricity consumption is determined from:

$$RECE = USFAC \times RECE\text{-}BASE \times \overline{TOYREL} \qquad [Eq. 29]$$

where

RECE-BASE	=	An input value in kWh/Month (cf. Page 1 of Table 3.14) scaled to the number of billing period days;
$\overline{TOYREL}$	=	Daily averaged TOYREL over the billing period; and
USFAC	=	1 if the refrigerator is located in the heated space, and
	=	(TIUSAV-21.5)/(75-21.5) if the refrigerator is located in the unheated space

The values of TIUSAV (unheated space average temperature) are determined as discussed under Freezers. The scaling of consumption if the refrigerator is in the unheated space is in direct proportion to the estimated delta-temperature from inside to outside the refrigerator as compared to a nominal value of

$$75 - 21.5 = 53.5^{\circ}F.$$

$75^{\circ}F$ is the nominal room temperature for a heated space and $21.5^{\circ}F$ is an average of a typical freezer compartment temperature of $5^{\circ}F$ and a typical general refrigerated compartment temperature of $38^{\circ}F$.

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As many as three refrigerators may be included in a household. The consumption of each is calculated independently and summed for the final result.

3.4.11 Ranges and Ovens

Ranges and ovens are treated in the NAUP as Surface Units and Ovens. Monthly scale factors for electricity and natural gas consumption are based on Table 3.11 with the following results:

Month	Time-of-Year Relative Consumption (TOYREL)	
	Surface Units	Ovens
January	1.16	1.22
February	1.16	1.08
March	0.97	1.00
April	0.89	0.98
May	1.24	0.88
June	0.71	0.84
July	0.69	0.73
August	0.91	0.75
September	0.96	0.92
October	1.07	1.17
November	1.15	1.17
December	1.08	1.23

The occupancy scale factor for surface units and ovens, gas and electric, is based on Table 3.9 as follows:

$$NOCCREL = (1.22 + 0.24 \times NOCC)/2.18 \qquad [Eq.\ 30]$$

which results in the following values:

Number of Occupants (NOCC)	NOCCREL
1	0.67
2	0.78
3	0.89
4	1.00
5	1.11
6	1.22

The form of the equations for calculating the average consumption for both fuels, and for both Surface Units and Ovens is as follows:

$$\text{Consumption} = \text{BASE} \times \overline{\text{TOYREL}} \times \text{NOCCREL} \qquad [\text{Eq. } 31]$$

The BASE values of consumption for a family of four are assumed to be as follows:

Electric

Surface Units:	370 kWh/year
Ovens:	370 kWh/year

Natural Gas

Surface Units:	2.26 million Btu/year exclusive of standing pilot lights
Ovens:	2.70 million Btu/year exclusive of standing pilot lights

Standing pilot lights are treated as baseload as discussed in Section 3.4.3. The annual values of consumption listed above are converted to BASE values by scaling according to the number of billing period days.

3.4.12 Televisions

The monthly scale factors for TV electricity consumption are based on a Pacific Gas & Electric Field Study[48] with the following results:

Month	Time-of-Year Relative Consumption (TOYREL)
Jan	1.113
Feb	1.073
Mar	1.019
Apr	0.958
May	0.917
June	0.856
July	0.861
Aug	0.917
Sept	1.002
Oct	1.042
Nov	1.106
Dec	1.063

The above values are intended to apply to the first-set, i.e. primary set, but in NUAP they are applied to all TV sets.

There are no occupancy factors for TV's. The annual hours of operation are varied depending on the number of TV's in the residence as follows:

TV Set	Annual ON Hours
1	2280
2	1000
3	500

The electricity consumption for each set is determined from

$$TVCE(I) = BASE(I) \times HRS(I) \times \overline{TOYREL} \qquad [\text{Eq. } 32]$$

where

BASE(I)	=	The input value of power for the I-th set (cf. Page 1 of Table 3.14),
HRS(I)	=	Annual ON hours for the I-th set adjusted for the number of days in the billing period, and
$\overline{TOYREL}$	=	Daily average value of TOYREL

The total TV electricity consumption is simply the sum of the consumption of the individual sets.

3.4.13 Water Heaters - Electric

Seasonal variations in water heater energy consumption are caused by several factors:

1. Variations in demand;
2. Variations in inlet water temperature; and
3. Variations in the room temperature in which the water heater is located.

NAUP assumes no variation in inlet water temperature, but does incorporate the other two factors explicitly. Thus there are no monthly scale factors associated with the water heater calculations.

The DOE equation for electric water heater energy consumption is used in NAUP as follows:

$$BTUPD = \frac{100 \bullet CP \bullet GPD \bullet DTW}{ER}$$

$$+ HPD \bullet CP \bullet WHVN \bullet TWMTA \bullet \frac{S}{100}$$

$$\bullet \left[1 - \frac{CP \bullet GPD \bullet DTW \bullet 100}{HPD \bullet 3.413 \bullet WHBPE \bullet ER} \right] \quad \text{[Eq. 33]}$$

where

BTUPD = Electricity energy consumption in Btu/Day,

ER = Recovery efficiency assumed to be 100 percent,

S = Standby loss assumed to be 1.54 percent,

DTW = Temperature rise of the water from inlet to outlet, assumed to be 85 ^{o}F,

CP = Specific heat of water or 8.331 Btu/Gal/^{o}F,

HPD = Hours per day or 24, and

GPD = Daily demand in Gal/Day, which is an input to the water heater calculation determined elsewhere in NNAUP as described elsewhere,

TWMTA = Hot water temperature, which is assumed to be 145 ^{o}F, minus the room ambient temperature.

The room ambient temperature is the heated space temperature if the water heater is located in the heated space, and the average unheated space temperature, TIUSAV, otherwise. The seasonal dependence of these values is discussed in Section 3.4.8 for Freezers.

The final two variables in the governing equation are the water heater net volume, WHVN, and water heater electric heating element power, WHBPE, which are determined by scaling according to established values for particular "nominal" capacity products as follows:

$$WHVN = \frac{38.6}{40} \bullet WHCAP \qquad [Eq.\ 34]$$

and

$$WHBPE = \frac{WHCAP}{52} \bullet 9000 \qquad [Eq.\ 35]$$

where

WHCAP = nominal capacity in gallons;

i.e., it is assumed that a 40 gallon water heater has 38.6 gallons net volume, and a 52 gallon water heater has 9000 W of burner power. The nominal relationships are assumed to be valid over the limited range of water heater capacities found in residences. The consumption for the billing period is determined from

$$WHCE = \frac{BTUPD}{3413} \bullet (\#\ BP\ Days)\ . \qquad [Eq.\ 36]$$

where 3413 converts Btu/Day to kWh/Day.

3.4.14 Water Heaters - Natural Gas

The calculation of the natural gas consumption of natural gas water heaters is based on the same principals as described above for electric water heaters. If the following substitutions are made in the equation for electric water heaters, it is converted to the equation utilized in NAUP for natural gas water heaters:

BTUPD ⟶ BTUPDT:	The total Btu/Day from which standing pilot energy consumption is subtracted,
3.413 x WHBPE ⟶ WHBPG:	The burner power in Btu/h rather than watts.

Two of the parameters are assumed to have different values for electric and gas water heaters as follows:

		Gas	Electric
ER:	Recovery Efficiency	72%	100%
S:	Standby Loss	6%/hour	1.54%/hour

Also the burner power for gas water heaters is assumed to be

$$WHBPG = \frac{WHCAP}{40} \cdot 45000 \qquad [Eq.\ 37]$$

i.e., a 40 gal water heater is assumed to have a 45000 Btu/h burner.

The assumed standby losses and BTUPDT include the pilot energy consumption which is accounted for elsewhere. Thus the water heater model calculates the net natural gas consumption according to:

$$\text{BTUPDN} = \text{BTDPDT} - \text{BTUPDP} \qquad \text{[Eq. 38]}$$

where

BTUPDP = Daily pilot Btu consumption disused in Section 3.4.3.

The natural gas water heater energy consumption is determined from

$$\text{WHCN} = \frac{\text{BTUPDN}}{1021} \bullet (\text{\# BP Days}) \quad , \qquad \text{[Eq. 39]}$$

where it is assumed that one cubic foot of natural gas has a heating value of 1021 Btu.

3.4.15 Internal Load

The internal load is determined by summing load components over all heated space energy consumers and occupants. Table 3.17 identifies the components and how they are treated in NAUP. Occupants are assumed to be in the heated space only 50% of the time on average.

3.5 NORM SPACE CONDITIONING CALCULATIONAL PROCEDURES

Reviewing all of the methoas discussed in Section 3.2, it was concluded that the HEAP program satisfied most of the

Table 3.17. Intern Load Components

Item	Algorithm in NAUP
Clothes Dryer:	
Electric	16% of total consumption.
Gas: Main Burner	16% of main burner consumption.
Gas: Standing Pilot	70% pilot consumption.
Clothes Washer-Electric	100%
Dishwasher-Electric	100%
Freezer	100%
Furnace	No discrete component. Assumed incorporated in furnace efficiency. Furnace pilot assumed OFF in cooling season.
Lighting	100%
Refrigerators	100%
Ranges & Ovens	100%, including standby pilots, if any.
Television	100%
Water Heater:	
Gas	70% standby pilot consumption.
Electric	Difference between ideal heat required and actual consumption.
Hot Water Energy	50% ideal energy input less clothes washer water if clothes washer is located in unheated space.
Electric Baseload	100%
Natural Gas Baseload	Treated pilot by pilot as noted above.
Occupants	50% of 500 Btu/h per occupant.

criteria discussed in Section 2. To gain a better appreciation of its capabilities and required modifications, this program and its factors will be discussed here in detail. The load determination aspects of the HEAP program are discussed immediately below, and the equipment characteristics that are used to calculate the energy consumption of space conditioning equipment are discussed in Section 3.5.2.

3.5.1 Norm Load Determination

The HEAP program shows potential because it considers all of the necessary aspects of building heating and cooling and is very economical to run. The program requires about 35K actual of DEC-10 computer memory and takes approximately 5 sec of execution time for a yearly analysis. HEAP consists of a main program, 19 subroutines, and 4 function routines.

HEAP is based upon the more complex and sophisticated load determination program NBSLD, but is a much faster running program. NBSLD uses hour-by-hour data, whereas HEAP uses long-term monthly average weather data to compute heating and cooling loads. Sensible heat gain or loss and latent heat gain or loss, if any, are determined for the following components:

1. Wall heat transfer due to conduction and solar absorption
2. Window heat transfer due to conduction and solar transmission
3. Door heat transfer due to conduction and solar absorption
4. Ceiling heat transfer due to conduction (considers complete attic and roof analysis)
5. Floor heat transfer due to conduction (considers complete analysis of basement, crawl space or slab or grade or combinations)

6. Internal heat generation including that due to occupancy, lighting, furnace and appliances

7. Infiltration losses

8. Domestic hot water

The HEAP program was initially designed to handle one-story buildings, but has been modified to handle multi-story structures. Figure 3.3 shows a flow chart of the HEAP program. The basic calculational scheme is to determine daytime and nighttime heat gains or losses separately for all the major heat exchange components. Since the calculational methodology treats the building heat transfer as a steady-state problem, the time lag and thermal storage phenomena are not considered as they are in more sophisticated codes like NBSLD or BLAST. In order to account for this, the program uses a "storage load factor" (SLF) which determines the portion of daytime heat gain that can be used of offset the nighttime heat loss (when such a phenomenon takes place). However, if both the daytime and nighttime experience heat gains or losses, they are simply summed to get the total.

The average-day heating and cooling requirements are computed for all twelve months, and an annual summary energy requirement is determined. A summary of the data requirement is shown in Figure 3.4. Specifically, the data include:

I. Weather Data

1. daytime average temperature

2. nighttime average temperature

3. total solar radiation upon the horizontal surface

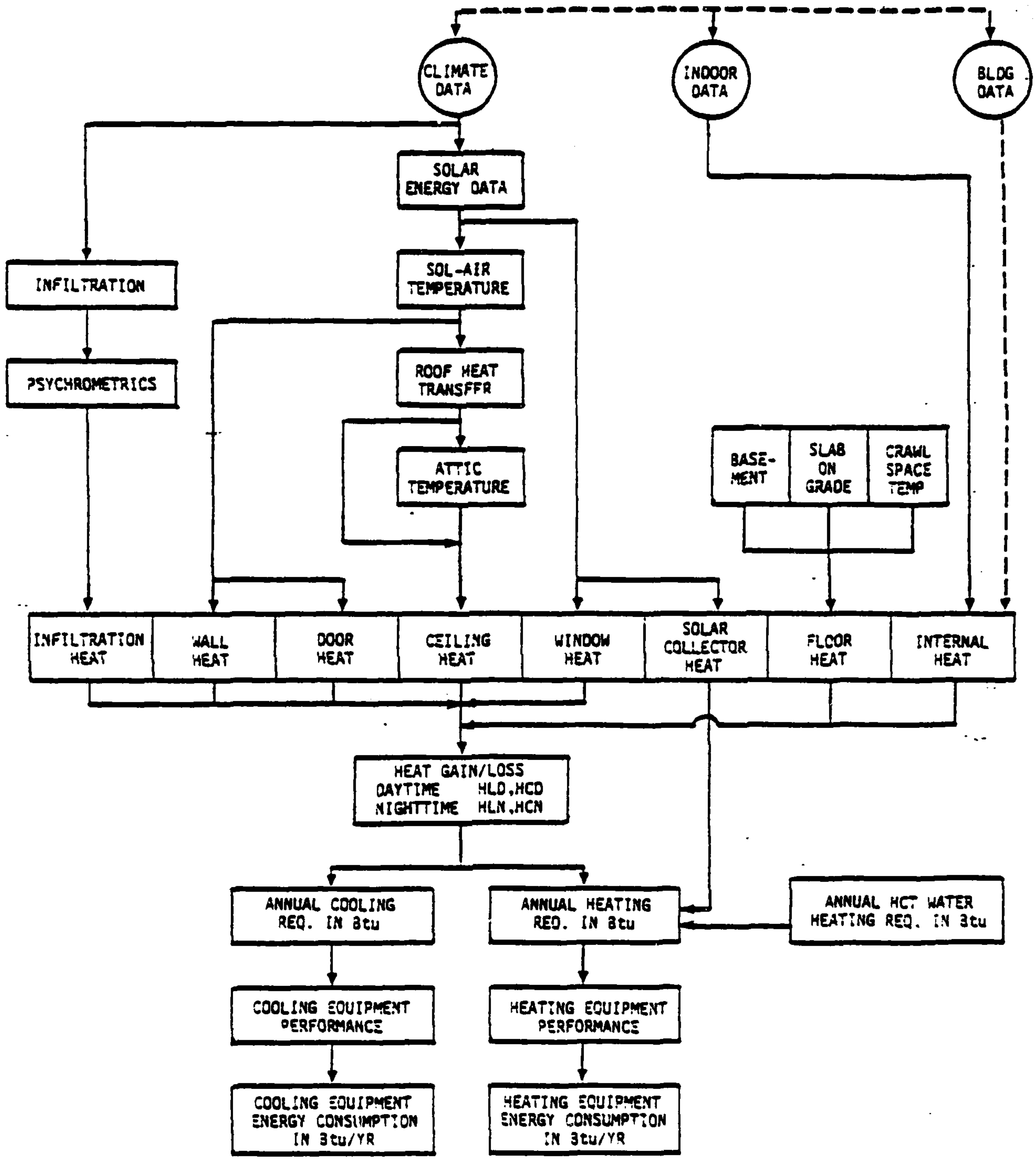

Figure 3.3. Flow Chart of the Heating and Cooling Load Program

OPERATION CONSERVE INPUT DATA

BUILDING NAME ______________________

TYPE ______________________

LOCATION, LATITUDE, ZIPCODE ZONE

Climatic Data (Monthly)
TOT: Daily average temp
TOD: Daytime average temp
RH: Relative humidity
WS: Wind speed
H: Daily total horizontal solar insolation
ZT: Liu/Jordan Factor
RHO: Ground surface reflectance

Standard Air Leakage Data
ACHS: Room air change/hr
ACAT: Attic space air change/hr
ACCS: Crawl space air change/hr
ACNV: Natural ventilation air change/hr

Building Mass Data
THTC: Thermal Time Constant

Envelope Data		I Type	A Area	U U	AB Solar Abs	SHDW Shadow Factor	SC Shading Coeff.	WAZ Orienta-tion	WILT Tilt	ZL Perimeter Length
Roof		1							0	
Ceiling		2								
Attic End Walls		3							90	
Walls	1	4							90	
	2	4							90	
	3	4							90	
	4	4							90	
Windows	1	5							90	
	2	5							90	
	3	5							90	
	4	5							90	
Doors (4 sides)		6							90	
Slab on Grade		7								
Basement		8								
Crawl Space		9								
Basement Wall		10								
Solar Collector		11						0		

Equipment Data (Seasonal average)

EG: Gas furnace efficiency
EB: Boiler efficiency
COP: Air conditioner COP
SA,SB: Solar collector efficiency factors

Indoor Data - Seasonal (Winter/Summer)
NP: Number of occupants
WT: Lighting power, Watt
WE: Equipment power, Watt
TID: Daytime thermostat setting
TIN: Nighttime thermostat setting
RKIN: Indoor humidity level

Figure 3.4. Data Needed for the Heating and Cooling Load Calculations

4. average relative humidity (morning and afternoon)

5. average windspeed

6. ground temperature

II. Envelope Data

1. total areas and U-values for roof, ceiling, gable or end walls of attic, vertical walls, windows, doors, slab-on-grade floor, basement floor, floor over crawl space, basement walls and solar collector, if any

2. solar absorptivity of exterior walls

3. shadow factor (shade produced by trees, etc.)

4. shading coefficient (internal devices such as blinds)

5. wall orientation (latitude, azimuth-angle)

6. wall or window tilt angle

III. Other Data

1. Liu/Jordan constants

2. ground reflectance

3. incident total solar radiation

4. incident sky radiation

5. volume of rooms

6. air change data

7. indoor temperature (day and night)

8. air leakage rate

9. floor exposed perimeter length

10. mechanical ventilation in attic (or natural)

11. hot water inlet and outlet temperatures

12. hot water usage

13. internal generation rates

HEAP has been verified against BLAST calculations to ensure its adequacy. These verifications will be discussed later. HEAP runs very quickly on the computer, but can be made even faster by streamlining the programming and removing the one-time calculations from the program and storing them on a file. It should be emphasized that BLAST, or equivalent programs, calculations are required to verify and validate HEAP and that such calculations may be used to generate additional weighting factors for HEAP.

Because HEAP appears to be the only existing simple load method with sufficient flexibility to analyze a variety of house types, DOE is considering additional work on this program with a possibility of putting it on one or more solid-state chips for a handheld calculator. Whether this will become a reality remains to be seen, but it indicates the importance of the method and its potential to provide adequate loads.

SAI has investigated HEAP in great detail and reconstructed many of the algorithms that were in the program, because the available documentation was almost non-existent. The program was obtained from the National Bureau of Standards in the form of an updated listing, but the documentation was said to be in preparation.

The appropriateness of the choice of HEAP as the methodology for calculating the energy norm was confirmed based on the preliminary results of an AIA (American Institute of Architecture) survey of load calculational procedures. These

results showed no known simplified load calculational techniques. It appears that the HEAP method is the simplest available, aside from the traditional heating and cooling degree-day and bin methods.

To apply HEAP to the norm process required some modifications and improvements as discussed below. A listing of the HEAP procedure as modified for use as the space conditioning energy consumption component of the Norm procedure is presented in Appendix B.

3.5.1.1 Weather Data Modifications

A method was required to integrate the available weather data into HEAP so that heating and cooling requirements could be determined. Figure 3.5 shows a basic block diagram of the approach developed. The weather data are fed into a preprocessor algorithm. This algorithm performs two functions. First, it determines the daytime and nighttime temperatures suitable for heating and/or cooling calculations with HEAP. Second, it determines the number of days of heating and/or cooling for that billing period. Standard HEAP calculations are used to determine the heating and cooling requirements for billing period in question, for the average conditions determined from the weather data preprocessing.

Several procedures have been developed to derive the required data for HEAP from the measured meteorological data. The most crucial one is the determination of the appropriate ambient temperatures. The HEAP program requires average daytime and nighttime dry bulb temperatures and humidities. Since the meteorological data acquisition system has to be simple, the maximum and minimum daily temperatures are utilized to construct

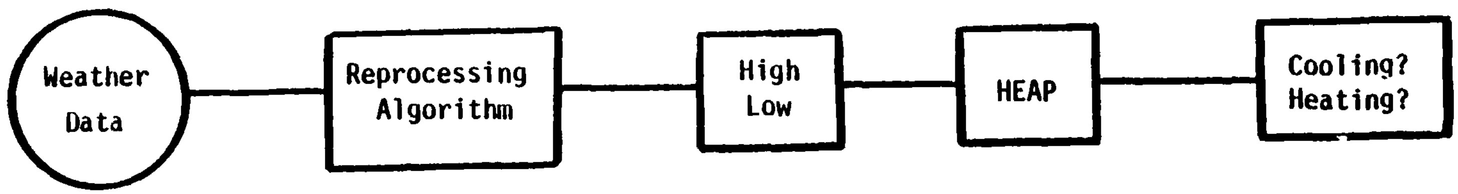

Figure 3.5. Weather Data Processing Flow

models from which all necessary temperature data is derived. For example, the average daily temperature is computed as the average of the maximum and minimum temperatures of that day. The accuracy of this model is shown in Figures 3.6 and 3.7, where the average dry bulb and wet bulb temperatures, as computed using a whole year of hourly measured temperatures, are compared against the value as computed using the average of the maximum and minimum temperatures of that day. As can be seen these comparisons show that the model is acceptable. This model is most suitable for those months that are heating or cooling only. When a period contains both, days that are heating and days that are cooling, the model is not applicable. Several attempts were made to derive a more suitable procedure, but none was totally successful. Inaccuracies in this model, however, have a small impact on the total annual energy consumption. Better algorithms need to be developed for this situation. For certain equipment performance calculations, daily temperature profiles are needed and the maximum and minimum measured values are used to construct these. Section 3.5.2 provides more detail on the construction of these profiles.

3.5.2 Space Conditioning Energy Consumption Calculations

3.5.2.1 General

Space conditioning energy consumption for furnaces is determined by dividing the total heating load for the billing period as determined above by the furnace efficiency. Natural gas, oil and electric furnaces are accomodated by the space conditioning program by setting a flag indicating which type is present. The furnace efficiency is an input for all furnace types, and consumption is output in cubic feet of natural gas, gallons of oil or kWh of electricity as appropriate.

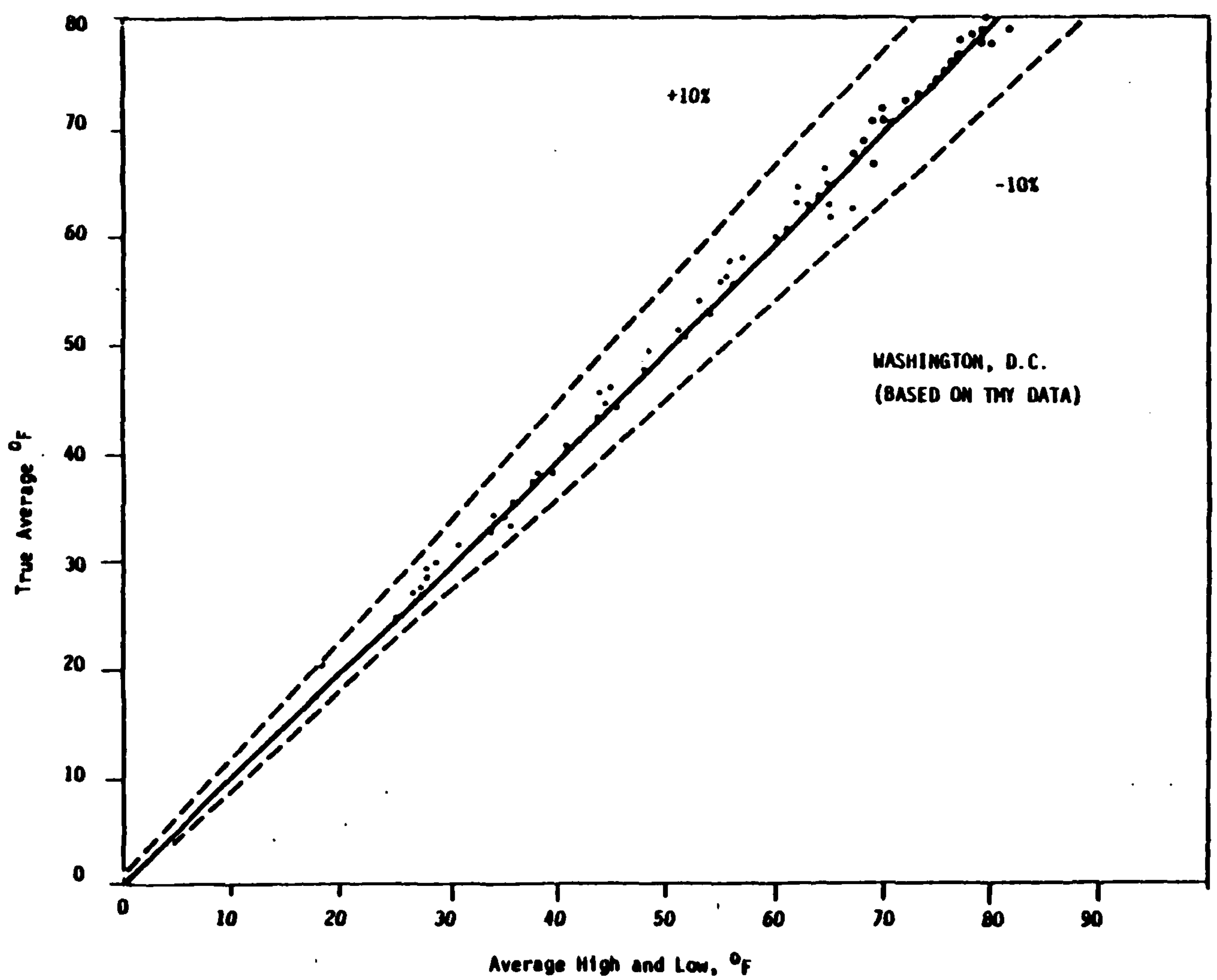

Figure 3.6. Average Daily Dry-Bulb Temperature

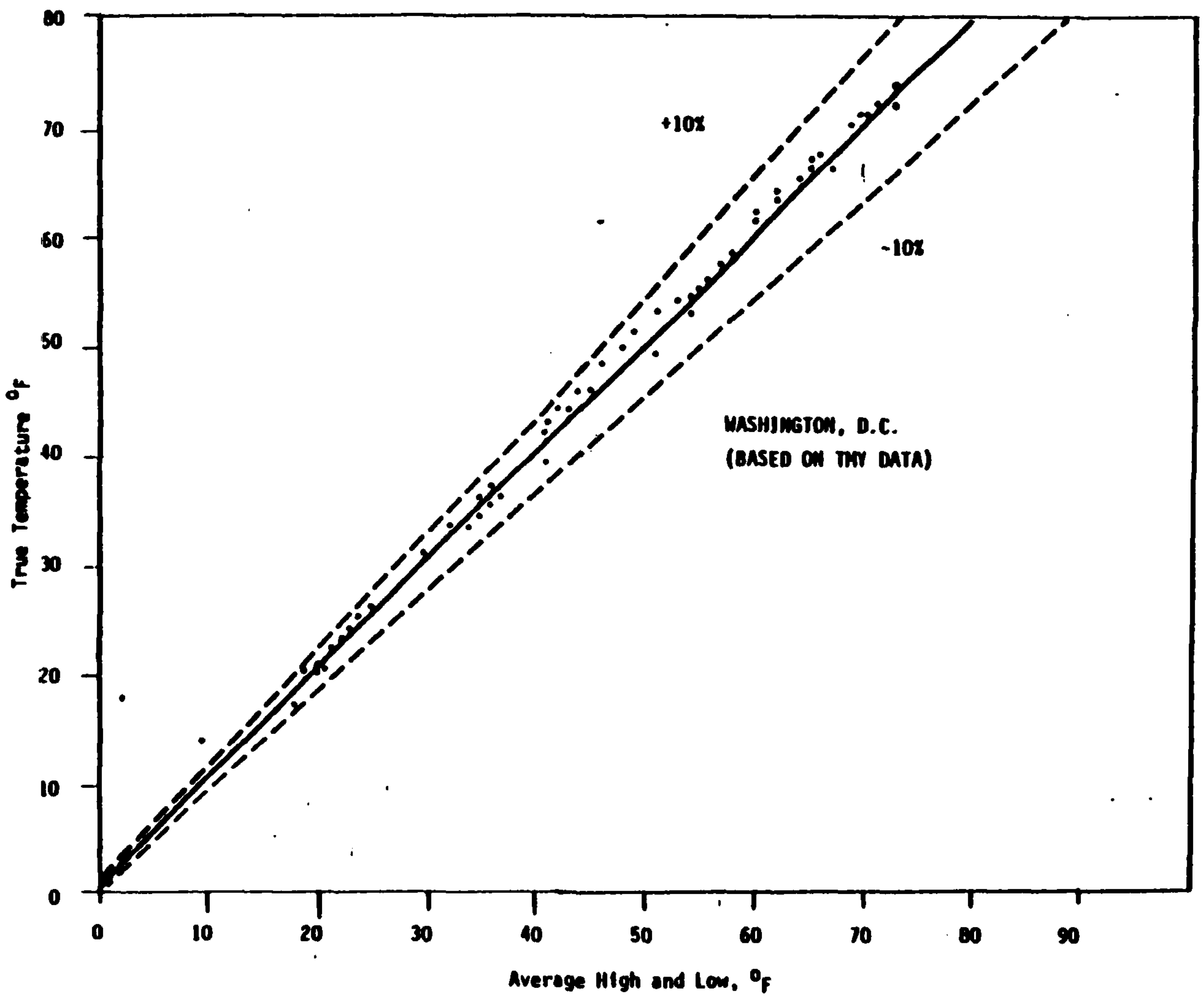

Figure 3.7. Average Daily Wet-Bulb Temperature

Most of the effort concerning equipment modifications for HEAP was exerted in the development of a central air conditioner (CAC) performance model. The reasons that CAC's received special attention are as follows:

- o The field test program was conducted in the summer months when space cooling and not space heating was of interest, and
- o The original version of HEAP did not include a CAC performance model.

The early versions of HEAP accepted a "seasonal energy efficiency" as an input for determining CAC energy consumption. In actuality seasonal CAC efficiency is a result, not an input. The distinction might not be significant under some conditions such as over long time periods for which errors tend to average out; or for conditions for which a simple relationship exists between seasonal efficiency and rated efficiency. However, for NORM purposes, it cannot be assumed that the desired conditions will exist. For example, the billing period may be short or it may be "unseasonably" warm during the billing period.

No single CAC efficiency number is adequate to accommodate accurately the expected variation in billing period cooling conditions. Thus a CAC performance model was developed expressly for the NORM space cooling calculations.

3.5.2.2 The Norm CAC Model

The CAC model is composed of three modules:

1. A product performance module,
2. A weather module, and
3. An energy efficiency calculation module.

The product performance module determines the power draw of the CAC as a function of outdoor and indoor temperatures. The weather module fits the daily weather data to provide a daily temperature profile. The energy efficiency module combines the weather and product data to produce quarter-hourly estimates of energy efficiency that are averaged over the billing period.

The Product Performance Module

Product performance is based on the published performance characteristics of a General Electric BWB 936A Condensing Unit with a BWV 936G air handler at 1200 cfm; the performance data are illustrated in Table 3.18. The range of data indicated in Table 3.18 has been extended to include all expected variations in outdoor and indoor dry and wet-bulb temperatures; the extended ranges are as follows:

- T^{o}_{db} : 65 to 115^{o}F
- T^{i}_{db} : Unlimited
- T^{i}_{wb} : 55 to 71^{o}F,

where subscripts of "db" and "wb" stand for dry-bulb and wet-bulb respectively, and superscripts of "o" and "i" stand for outdoor and indoor respectively. If the ranges are exceeded, the product performance at the appropriate limits are assumed, e.g., if T^{o}_{db} is 120^{o}F, the model performance is assumed to be that at 115^{o}F.

Table 3.19 is a computer printout of one set of product performance validation data. A comparison of the data of Tables 1 and 2 indicates the accuracy of the curve fits. Straight line curve fits are used throughout the performance model, and linear interpolation is used for intermediate values of the variables T^{o}_{db} T^{i}_{db} , and T^{i}_{wb}

Table 3.18. Baseline GE CAC Published Performance Characteristics

O.D. D.B.	I.D. W.B.	TOTAL CAP.	SENS. CAP. AT ENTERING D.B. TEMP. 72	74	76	78	80	COMPR. KW(1)	APP. DEW PT.(1)
85	59	31.4	26.6	28.7	30.8	31.8*	32.3*	3.4	46.5
	63	33.1	21.6	23.6	25.6	27.6	29.7	3.5	50.2
	67	34.8	16.9	18.8	20.7	22.6	24.5	3.6	53.8
	71	36.5	12.7	14.5	16.2	18.0	19.8	3.7	57.5
90	59	30.7	26.4	28.5	30.7*	31.2*	31.8*	3.6	47.0
	63	32.5	21.4	23.5	25.5	27.6	29.6	3.7	50.7
	67	34.3	16.7	18.7	20.6	22.5	24.5	3.8	54.3
	71	36.1	12.5	14.3	16.1	17.9	19.8	3.9	58.0
95	59	29.8	26.2	28.4	30.0*	30.6*	31.1*	3.7	47.6
	63	31.7	21.2	23.2	25.3	27.4	29.5	3.8	51.2
	67	33.6	16.5	18.5	20.5	22.5	24.4	3.9	54.9
	71	35.5	12.3	14.1	16.0	17.8	19.7	4.0	58.6
100	59	28.8	25.8	28.0	29.2*	29.8*	30.4*	3.8	48.1
	63	30.8	20.9	23.0	25.1	27.3	29.4	4.0	51.8
	67	32.7	16.3	18.3	20.3	22.3	24.3	4.1	55.5
	71	34.7	12.0	13.9	15.8	17.6	19.5	4.2	59.1
105	59	27.6	25.4	27.6*	28.3*	28.9*	29.6*	4.0	48.7
	63	29.7	20.6	22.7	24.9	27.1	29.2	4.1	52.4
	67	31.8	15.9	18.0	20.0	22.0	24.1	4.2	56.0
	71	33.9	11.7	13.6	15.5	17.4	19.4	4.4	59.7
115	59	25.0	24.3	25.6*	26.3*	26.9*	27.6*	4.3	49.8
	63	27.2	19.7	21.9	24.1	26.3	27.6*	4.4	53.6
	67	29.5	15.2	17.3	19.4	21.5	23.6	4.6	57.2
	71	31.7	10.9	12.9	14.9	16.9	19.0	4.7	61.0

CORRECTION FACTORS–OTHER AIRFLOWS
(Multiply or add as indicated)

AIRFLOW	1050	1200	1350
TOTAL CAP.	x .975	x 1.000	x 1.025
SENS. CAP.	x .95	x 1.00	x 1.05
COMPR. KW	x .99	x 1.0	x 1.01
ADP	−1.0	.0	+ 1.0

VALUES AT ARI RATING CONDITIONS

TOTAL CAPACITY = 34000 BTUH
AIRFLOW = 1275 CFM
APP. DEW PT. = 55.4 DEG. F
COMPRESSOR POWER = 3940 WATTS
I.D. FAN POWER = 500 WATTS
O.D. FAN POWER = 410 WATTS
ENERGY EFF. RATIO = 7.0 BTUH/WATT

NOTE: RATED WITH 25 FEET OF 3/4 SUCT. AND 5/16 LIQUID LINES

*Dry coil condition (Total capacity = Sensible capacity)
(1) Comp. KW and App. Dew Pt. are valid only for wet coil

Table 3.19. Sample CAC Performance Model Results

TODB = 95.00 DEG-F. TIDB = 78.00 DEG-F.

TIWB	TOTCAP	SENSCAP	LATCAP	DRYCAP	CPPWR	TOTPWR	EERACT	EERREL
55.0	27900.0	30534.0	0.0	30534.0	3600.0	4510.0	6.19	0.882
59.0	29800.0	30534.0	0.0	30534.0	3700.0	4610.0	6.46	0.922
63.0	31700.0	27500.0	4200.0	30534.0	3800.0	4710.0	6.73	0.960
67.0	33600.0	22500.0	11100.0	30534.0	3900.0	4810.0	6.99	0.996
71.0	35500.0	18000.0	17500.0	30534.0	4000.0	4910.0	7.23	1.031

The last two columns of Table 3.19 illustrate the variations of product efficiency with one of the variables, T_{wb}^{i}. EERACT is the Energy Efficiency Ratio (EER) of the GE product at the conditions indicated. EERREL is the relative EER of the GE product at the specified operating conditions compared to its rated EER. As indicated in Table 3.18, the rated EER is 7.0.

EERREL is the main parameter of interest because it is used to determine an average EER for the billing period for any product. The average EER for the billing period for a specific product is determined by multiplying the average EERREL for the GE product by the rating point EER of the specific product; the latter is an input to the modified HEAP program.

The approach that has been implemented assumes that "off-rating-point" performance of the actual CAC will be approximately the same relative to rating point performance as it is for the GE product. The assumption is reasonable for most standard single speed compressor CAC's, and it is required because it is not practical to model every CAC separately. Approximately eight computer subroutines and forty curve fits are required for a single product model.

Thus, in summary, the product performance module models a "typical" CAC and scales the average billing period efficiency of the typical CAC to obtain an average billing period efficiency for the actual CAC. The only input variable for the actual CAC that is used is its rating point energy efficiency ratio.

The Weather Module

The weather data are modeled as illustrated in Figure 3.8. The inputs for the weather model are:

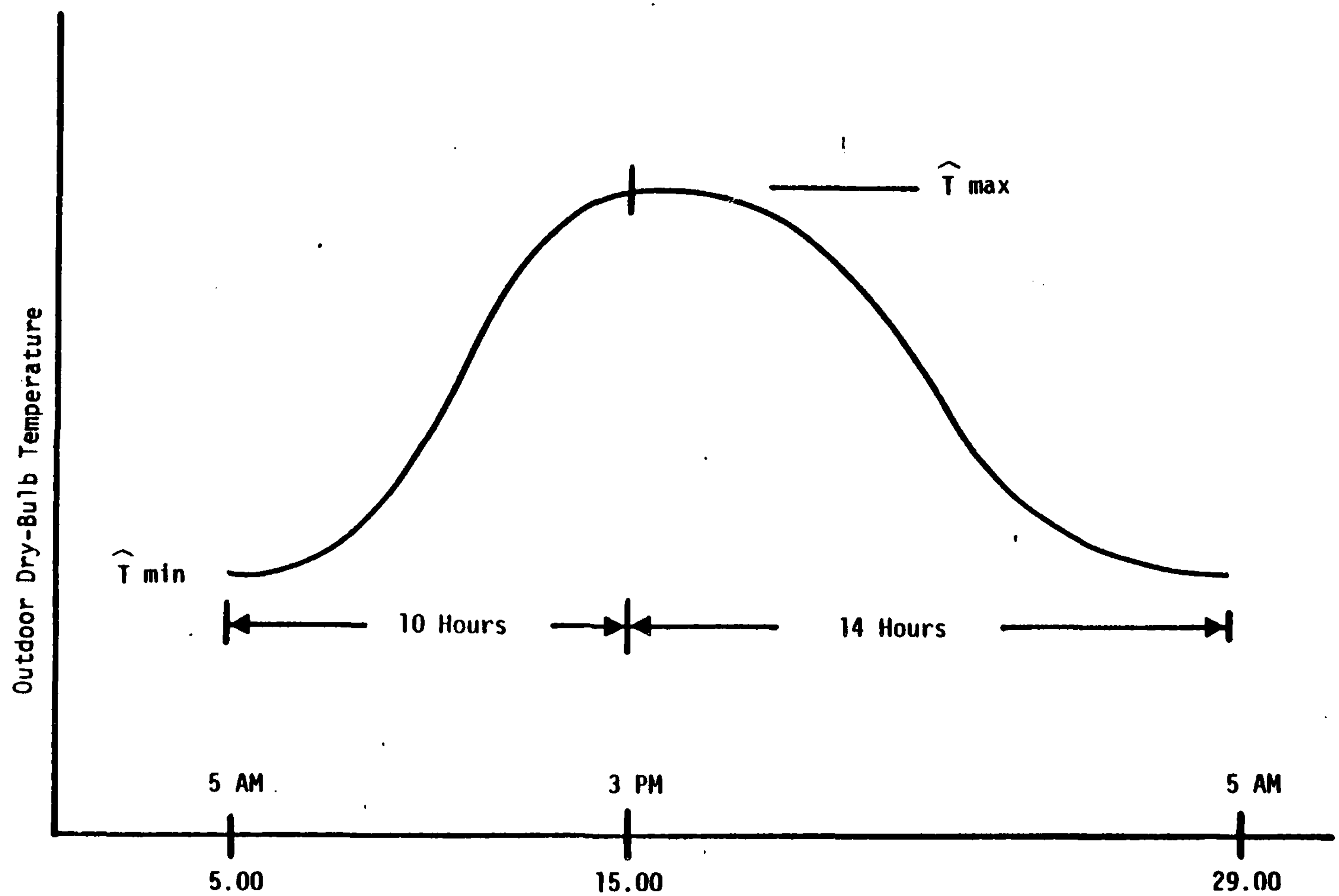

Figure 3.8. CAC Weather Model for Typical Day

- $\hat{T}_{max}$: the billing period average maximum outdoor dry-bulb temperature, and
- $\hat{T}_{min}$: the billing period average minimum outdoor dry-bulb temperature.

Both $\hat{T}_{max}$ and $\hat{T}_{min}$ are inputs to the modified HEAP program as discussed in Section 3.5.1.

The weather model assumes that $\hat{T}_{min}$ occurs at 5 a.m. and that $\hat{T}_{max}$ occurs at 3 p.m. The daily temperature profile is modeled as:

$$T\ (5\text{ a.m. to }3\text{ p.m.}) = \hat{T}_{min} + (\hat{T}_{max} - \hat{T}_{min}) \times \cos^2(\pi\ (t-15)/20) \quad \text{[Eq. 40]}$$

which rises from $\hat{T}_{min}$ at 5 a.m. or 500 hours to $\hat{T}_{max}$ at 3 p.m. or 1500 hours, and

$$T\ (3\text{ p.m. to }5\text{ a.m.}) = \hat{T}_{max} - (\hat{T}_{max} - \hat{T}_{min}) \times \cos^2(\pi\ (t-29)/28) \quad \text{[Eq. 41]}$$

which falls from $\hat{T}_{max}$ at 3 p.m. or 1500 hours to $\hat{T}_{min}$ at 5 a.m. or 2900 hours.

<u>The Energy Efficiency Calculation Module</u>

The representative day of Figure 3.8 is partitioned into 48 half-hour intervals. The indoor thermostat is allowed to have two values: a daytime (6 a.m. to 6 p.m.) and a nighttime (6 p.m. to 6 a.m.) setting. At each interval:

- T^o_{db} is determined from the weather model, i.e. the representative day of Figure 3.8,

- T^i_{db} is determined from the time of day and the thermostat setting for that time of day,

- RH^i, the indoor relative humidity, is assumed to be 50%

- T^i_{wb} is determined from T^i_{db} and RH^i in psychometric calculations, and

- EER is determined from the product model.

The average EER for the period is determined by averaging the half-hourly determinations of EER "appropriately." For a period segmented into "i" subperiods of Δt hours each, the energy consumption is given by

$$\text{Input Energy} = \sum_i \frac{q_i \Delta t_i}{EER_i} \qquad \text{[Eq. 42]}$$

where EER_i is the efficiency and q_i is the load at the i-th time step. The above equation implies that the appropriate expression for the average EER is

$$EERAVG = \frac{\sum_i q_i \Delta t_i}{\sum_i \frac{q_i \Delta t_i}{EER_i}} \qquad \text{[Eq. 43a]}$$

or

$$\text{EERAVG} = \frac{\sum_i q_i}{\sum_i \frac{q_i}{\text{EER}_i}} \qquad \text{[Eq. 43b]}$$

where the second equality follows if all the subperiods are of equal duration, which they are in the model (one half-hour each). In order to evaluate the above expression, the following assumption is made:

$$q_i = A \left\{ T^o_{db}(t_i) - [T^i_{db}(t_i) - 5] \right\} \qquad \text{[Eq. 44]}$$

i.e., the load at time t_i is proportional to the delta-temperature from indoors to outdoors at time t_i plus 5^oF. The 5^oF offset is intended to accomodate internal loads, which for example could produce a load on the cooling system even if the indoor temperature were 80^oF and the outdoor temperature were a lower 78^oF. Equivalently, zero heat balance is assumed to occur 5^oF below the thermostat setting.

With the simplifying assumption for load behavior, the expression for the average efficiency for the period becomes:

$$\text{EERAVG} = \frac{\sum_i A\ (T^o_{db} - (T^i_{db} - 5))}{\sum_i \frac{A\ (T^o_{db} - (T^i_{db} - 5))}{\text{EER}_i}} \qquad \text{[Eq. 45a]}$$

$$\text{EERAVG} = \frac{\sum_{i} (T^{o}_{db} - T^{i}_{db} + 5)}{\sum_{i} \frac{(T^{o}_{db} - T^{i}_{db} + 5)}{\text{EER}_i}} \qquad \text{[Eq. 45b]}$$

As noted above, all the parameters on the right hand side of the above equation are determined every half-hour from the weather and product performance models. Thus the summation can be performed and EERAVG determined.

The final steps in the CAC efficiency calculations are as follows:

$$\overline{\text{EERREL}} = \frac{\text{EERAVG}}{7.0} \qquad \text{[Eq. 46]}$$

i.e., the average relative efficiency of the baseline product is its average efficiency for the representative billing period day divided by its rating point EER of 7.0, and

$$\overline{\text{EER}}\ (\text{Actual CAC}) = \text{RPEER}\ (\text{Actual CAC}) \cdot \overline{\text{EERREL}} \qquad \text{[Eq. 47]}$$

The latter average EER is the value that is divided into the cooling load that is determined as described in Section 3.5.1 to determine the kWh of energy consumption of the CAC for the billing period.

It might be noted that one of the advantages of the approach implemented in the modified HEAP is that it treats days for which cooling is required only around the peak of the temperature profile in a reasonably realistic manner. For example, in Figure 3.8, if

$$\hat{T}_{min} = 60^{\circ}F,$$

and

$$\hat{T}_{max} = 80^{\circ}F,$$

and the thermostat is set at 80°F, the averaging that is done in the CAC model is performed only for those half-hour periods for which the outdoor temperature is 75°F or greater (i.e., temperatures 5°F below the thermostat setting and higher). Cooling is required only during a fraction of the day and the EER's are averaged only over that fraction. The resulting average EER could be expected to be more realistic than a value determined at the average temperature for the day, i.e. 72.5°F, or a value based on an average seasonal temperature, perhaps 85°F.

The CAC model was developed for HEAP so that the type of conditions illustrated could be treated more realistically and accurately than was formerly possible.

3.6 SENSITIVITY AND VALIDATION

The process of establishing confidence in the ability to predict the norm energy consumption is called validation. It has also been defined as testing the agreement between the behavior of a model and that of a physical system to establish the level of the confidence of the model. Procedures for

demonstrating the validity of a methodology are not well defined and are often specialized for a specific method. Work by SAI has identified a multilevel approach that works from detailed models and data toward simpler design or evaluation tools. At each level, validation relates to two questions. The first one is: "How well does the present model track a more detailed model or detailed data?" Answering that question measures the effect of unmodeled parameters. The second question is: "How well does the model track data of an equivalent level of detail?" The answer to this question provides a measure of the fidelity of the modeling process. The norm procedure is a model for calculating the energy consumption of a residential building and can thus be subjected to the validation process outlined above. Thus the modified HEAP program should be validated against a more detailed methodology and against field test data. This work will be reported here.

The detailed model chosen for validation of HEAP is the BLAST computer program. The Building Loads Analysis and System Thermodynamics (BLAST) program is a comprehensive set of subprograms for predicting energy consumption in buildings. This program consists of three major subprograms: (1) the space load predicting subprogram, which computes hourly space loads in a building or a zone based on user input and hourly weather data; (2) the air distribution system simulation subprogram, which uses the computed load and user inputs describing the building air-handling system to calculate hot water or steam, chilled water, and electric energy demands; and (3) the central plant simulation program, which simulates boilers, chillers, onsite power generation equipment, and solar energy systems, and computes monthly and annual fuel and electrical power consumption and plant life cycle cost. The BLAST program was developed by the U.S. Army Construction Engineering Research Laboratory

(CERL). The BLAST program was designed to analyze commercial buildings but, in the absence of any other suitable tool, was applied to residential buildings. The validation effort involving field test data is described in detail in Section 4. The remainder of this section deals with comparisons of HEAP against BLAST.

The software-to-software validation step, that is, the comparison of results obtained by two computer programs, assumes that one of them has previously been validated and found sufficiently accurate for the purposes at hand. Validation of BLAST, in the sense of the definition of validation given at the beginning of this section, has not been reported in the open literature. The fundamental concepts imbedded in BLAST contain many models of components that are linked together by a suitable mathematical framework which presumably replicate accepted practices and experiences. It is therefore assumed that the results obtained for a simulated building are correct. Whether such a building can actually be constructed in practice is sometimes doubtful. To gain greater confidence in the ability of modified HEAP to compare favorably with BLAST requires a detailed validation of BLAST itself. This process is beyond the scope of the present effort, but it must be emphasized that this should be done. The assumption is thus made that BLAST will provide accurate results that can be used to validate HEAP. Therefore, comparing results of BLAST and HEAP against each other will not show which code is more accurate. However, being able to obtain reasonable agreement between the two is important for the purposes of demonstrating that a less detailed and significantly faster running program can be used to simulate the building loads and therefore can be used as the norm procedure.

BLAST runs and modified HEAP runs were made for two house types, one being a typical townhouse with approximately 1200 square feet of living area built on a slab-on-grade. The second house examined was a detached rambler type house with a basement and about 1200 square feet of living area. Both houses have an attic space.

Each of the houses were analyzed for one year of weather for two climates, one being the Washington, D.C. area and the other being Bismarck, North Dakota. The results of the analysis show two general trends. First, modified HEAP always predicted heating requirements that were less than those given by BLAST. Secondly, HEAP always predicted cooling requirements that were greater than those given by BLAST. Figure 3.9 shows a typical plot of the results for the townhouse and Washington, D.C. Figure 3.10 and Figure 3.11 show a plot of all the monthly heating and cooling requirements respectively, data for both Washington and Bismarck. The 45° line represents 100% agreement between BLAST and HEAP. The dashed line represents the adjustment that can be made in HEAP results so that they always agree within 28% with BLAST for heating, cooling is somewhat worse.

It was found that some of the differences between the BLAST and HEAP are due to differences in algorithms of certain elements of the calculation. For example, air infiltration, heat gain by people, solar gain thru windows, etc. By matching these algorithms it was found that the agreement became much better, within 15% for heating and 25% for cooling. Additional work could result in even better agreement but was not believed to be justified at the present time.

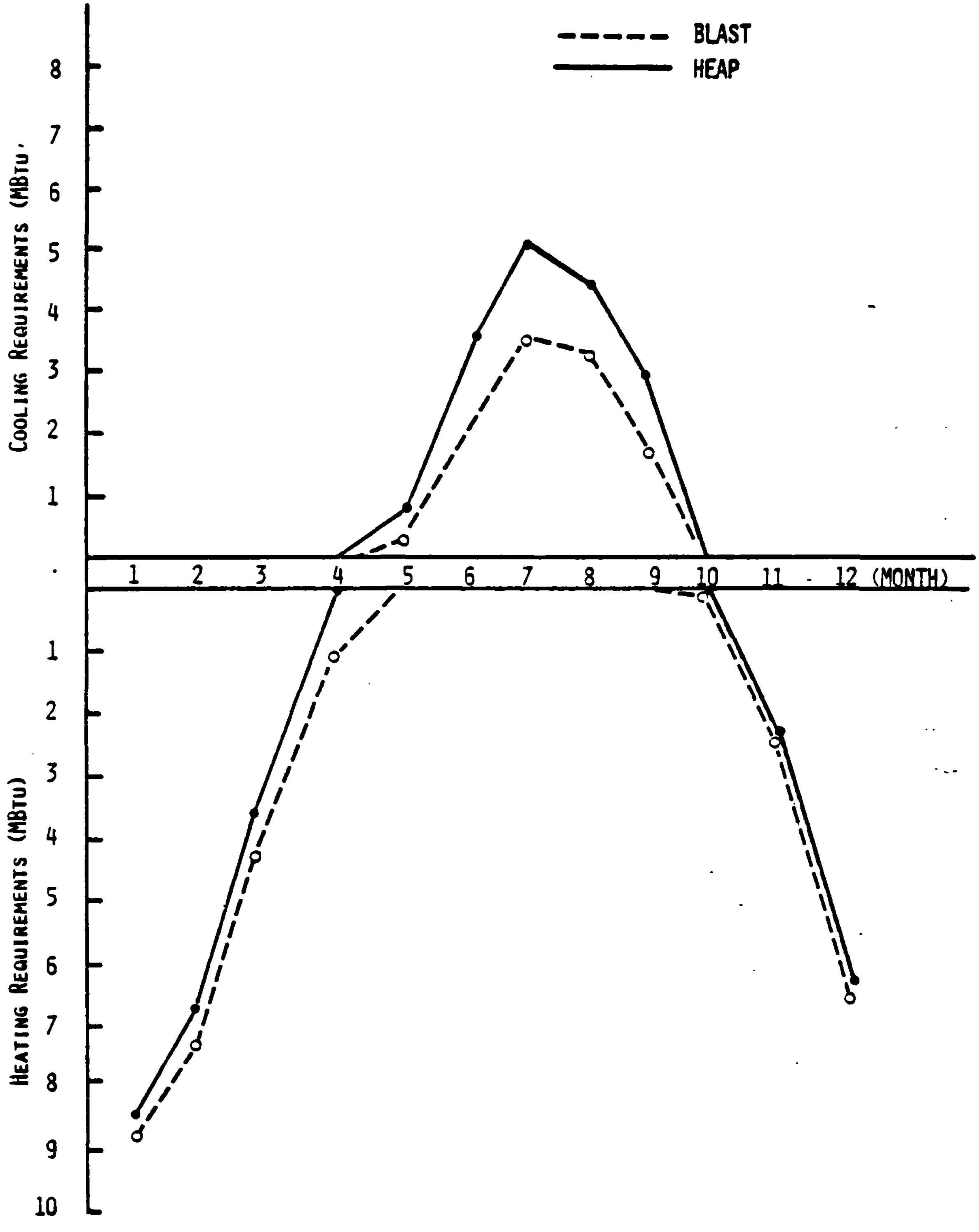

Figure 3.9. Comparison of HEAP and BLAST Monthly Heating and Cooling Requirements for a Washington, D.C. Townhouse

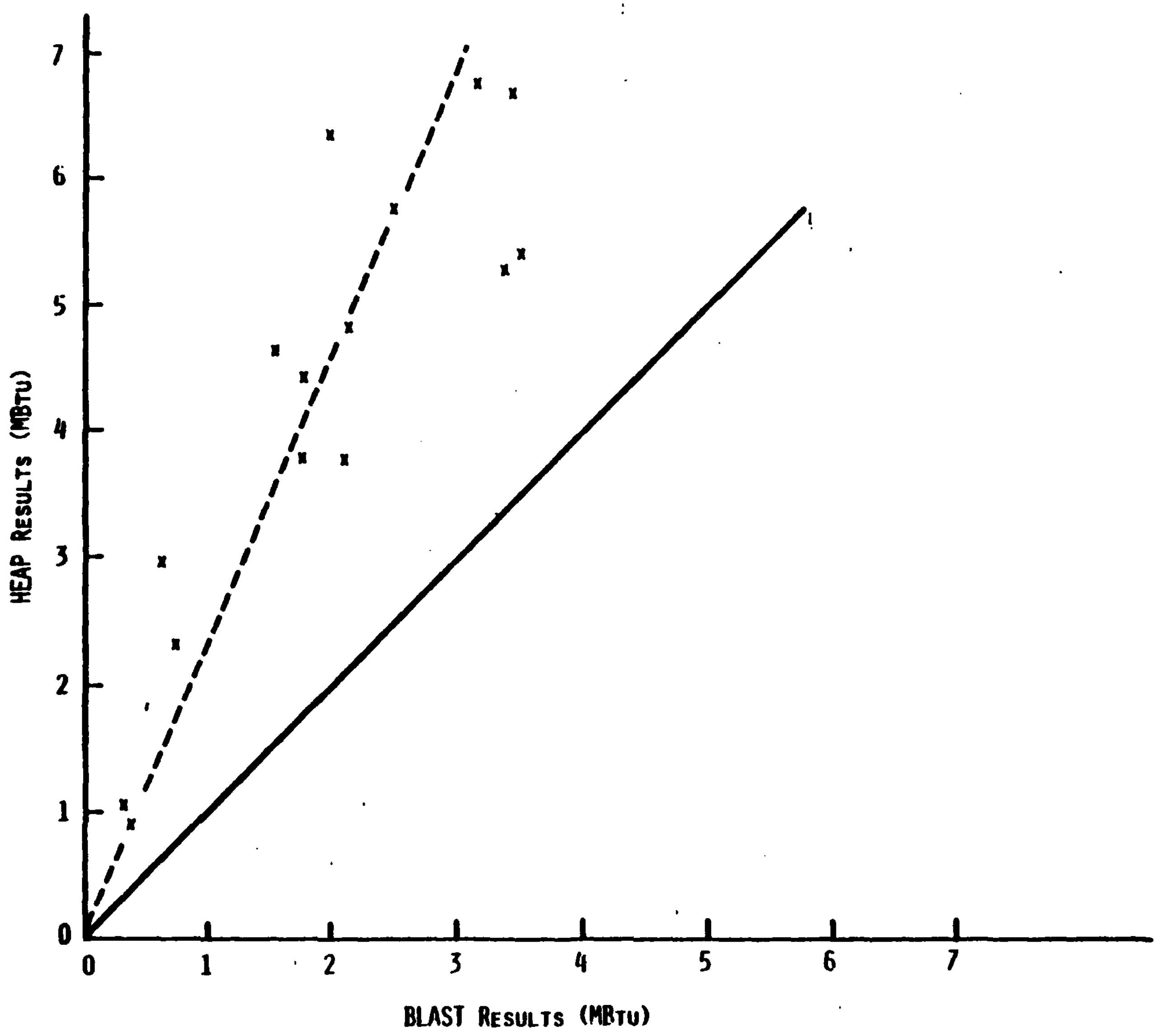

Figure 3.10. Comparison of HEAP [illegible]oling Results with BLAST for [illegible]

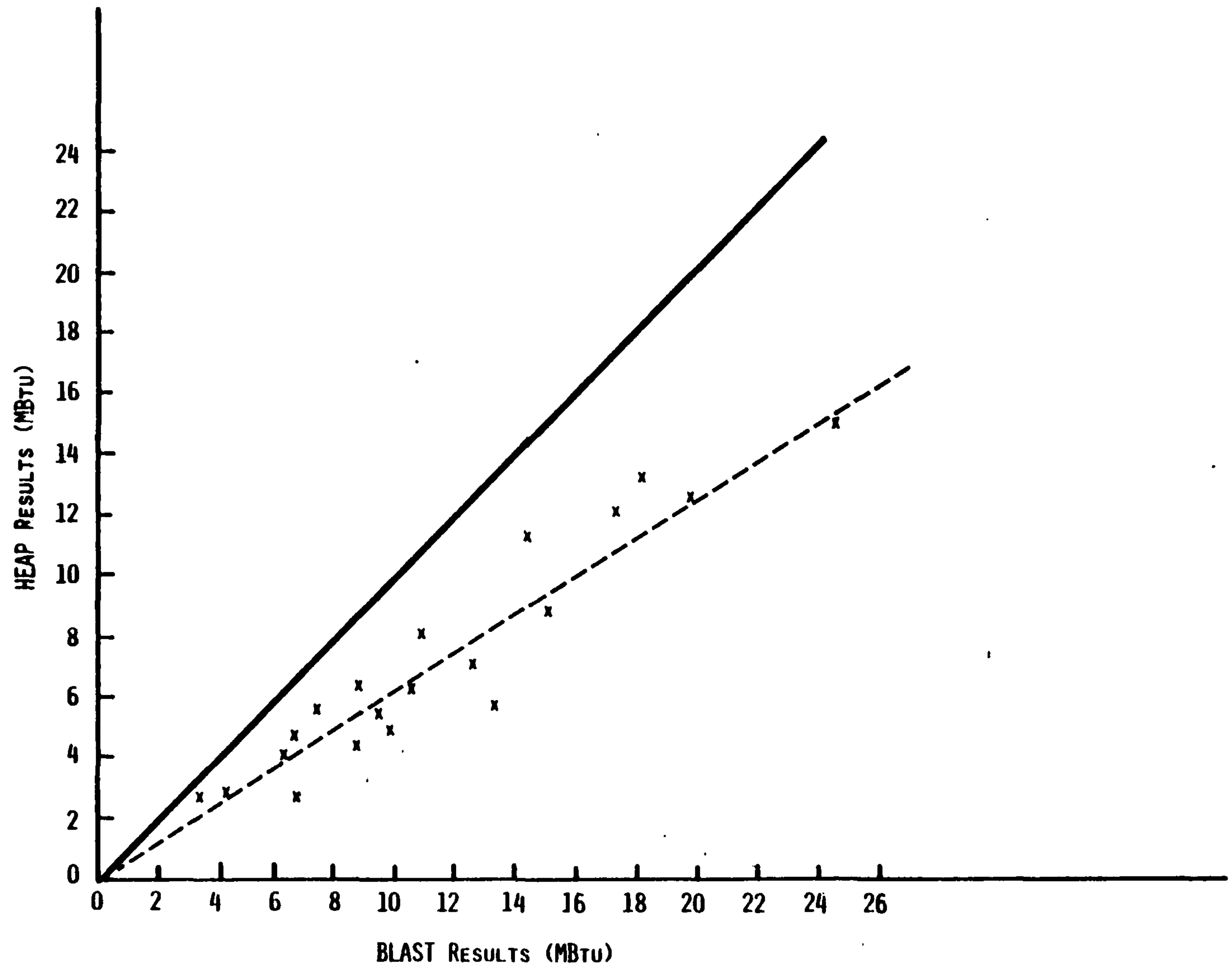

Figure 3.11 Comparison of HEAP Heating Results with BLAST for Washington, D.C. and Bismark, N.D.

As stated earlier, the current level of agreement between HEAP and BLAST does not provide information as to which code, if either, has acceptable accuracy. This can only be accomplished through comparisons with actual consumption data. Such comparisons have been made, to a limited extent, against the field test performed as part of this project. These results are discussed in detail in Section 4.9.

To gain confidence in the modified HEAP model, sensitivity analyses and comparisons of predictions against analyses with BLAST were performed. The first set of analyses were performed using a reference townhouse located in the Washington, D.C. area, and the results are shown in Table 3.20. The table shows the effect on the heating and cooling requirements when the respective parameter being examined is changed from some reference value, while all other parameters remain at reference conditions. The results show which parameters have the greatest impact on the heating and cooling requirements. Those parameters which most affect the heating and cooling requirements need to be determined as accurately as possible, so that HEAP does not overpredict or underpredict actual requirements.

Also examined as part of the sensitivity analysis were the effect of house orientation and the effect of opening windows for cooling when the outdoor temperature is lower than the indoor temperature. Figure 3.12 shows the effect on heating and cooling when the house takes on different orientations. It can be seen that the reference condition of 180° (front facing north) yields the minimal heating and cooling requirements, while a 90° rotation in either direction can have a large effect on cooling.

Table 3.20. HEAP Sensitivity Analysis Results

Parameter (reference value)	Values	% Change-Heating Req't	% Change-Cooling Req't
Wall-U Value (0.1 BTU/hr-ft^2-^{o}F)	0.05	-9.0	-7.0
	0.15	9.0	7.0
	0.20	18.0	14.0
Wall Surface Absorptivity (0.90)	0.4	2.0	-7.0
	0.7	0.8	-2.8
	1.0	-0.4	1.4
Roof Absorptivity (0.90)	0.4	1.0	-6.5
	0.7	0.4	-2.6
	1.0	-0.2	1.3
Shadow Factor (0.0)	0.5	7.5	-12.0
(Wall+Door+Window+Roof)	1.0	15.0	-24.0
Wall Shadow Factor (0.0)	0.5	1.0	-2.4
	1.0	2.0	-4.8
Roof Shadow Factor (0.0)	0.5	0.6	-3.7
	1.0	1.2	-7.4
Window Shading Coefficient (0.8)	0.0	21.0	-47.5
	0.55	6.0	-15.0
Building Air Changes/hour (.5)	1.0	11.5	0.5
	1.5	23.0	1.0
	2.0	34.5	1.5
Attic Air Changes/hour (3.0)	0	-0.5	1.5
	6	0.5	-1.0
	20	1.2	-4.0
Air Leakage Through Ducts (10%)	0	-5	-9.0
	40	15	27.0
	80	35	63
	100	45	81
Ground Reflectance (0.2)	0.4	2.75	16.0
	0.6	5.50	32.0
Thermal Time Constant (20)	10	0.51	—
	40	0.35	—

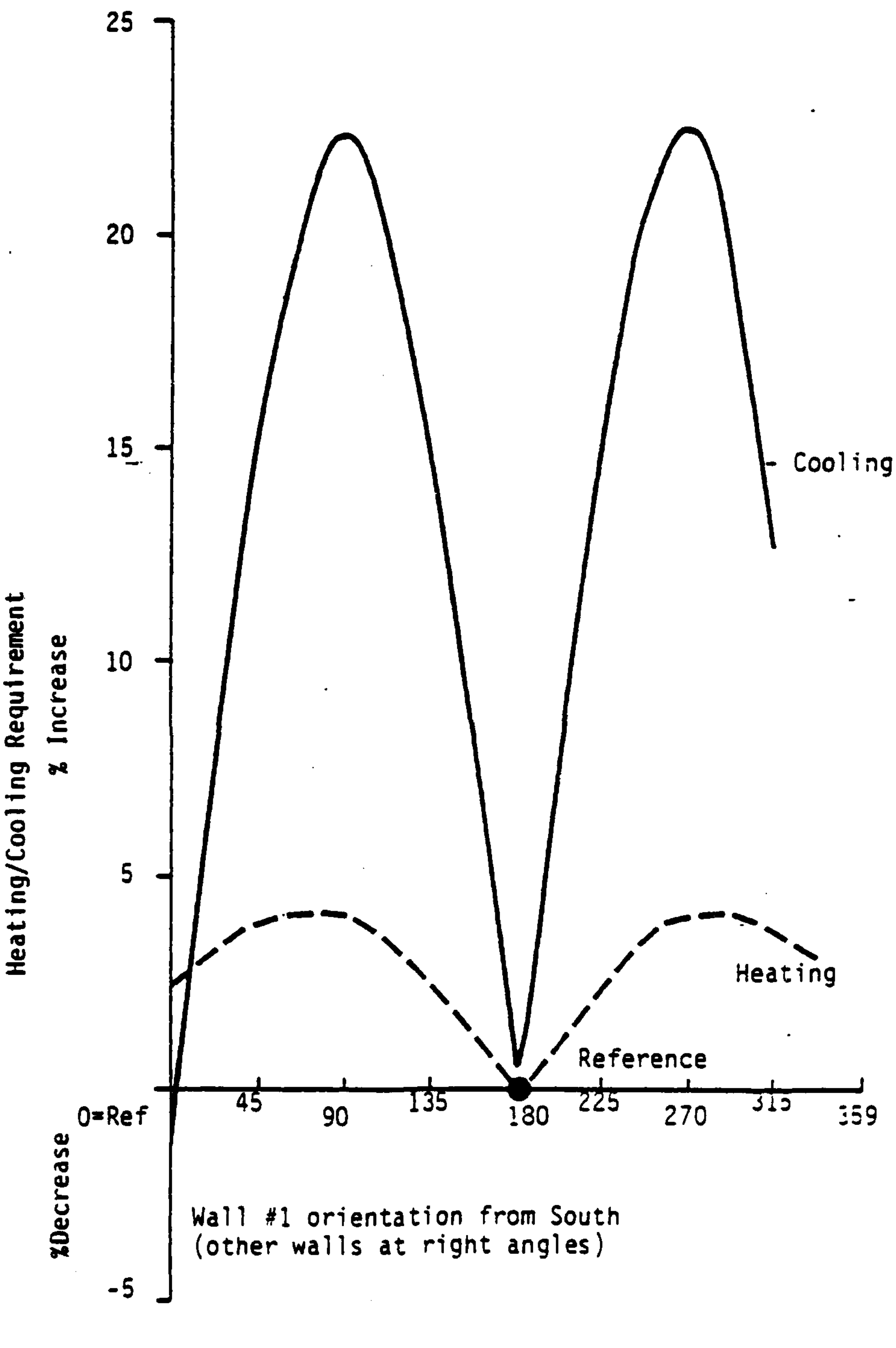

Figure 3.12 **Heating/Cooling (BTU) vs Wall Orientation**

3.7 INTEGRATION OF APPLIANCE UTILIZATION AND SPACE CONDITIONING PROGRAMS

Ultimately it is expected that the NAUP and modified HEAP would be integrated as one computer program. Presently, however, the two programs are separate, and the integration is performaed manually. The method is as follows:

1. Run NAUP;
2. Extract "The Average Internal Load During the BP" for the NAUP output (cf. Table 3.14, Page 3);
3. Run the modified HEAP using the internal load obtained from 2;
4. Sum the energy consumption results of NAUP and modified HEAP to determine the energy consumption for all purposes for the residence.

Thus there is one interface between the two programs which could readily and simply be eliminated.

4. VALIDATION AND ANALYSIS OF THE NORM PROCEDURE

The norm calculational procedure consisting of the modified HEAP program and NAUP procedure, discussed in Section 3, has been evaluated with data generated by a field test. Data requirements were defined when planning the field test program to provide a base for a limited validation and analysis of the norm procedure. The field test was set up to gather data for various buildings in different climatic zones with a range of occupancy characteristics. The following subsections discuss the implementation of the field test program and the resultant data analysis with respect to the accuracy of the norm procedure.

4.1 FIELD TEST PLAN

The field test program had three principal functions:

a) Preparation of a norm pamphlet which will explain the norm concept and the implementation of a norm program,

b) Acquisition of residence data and two months (July 16 through September 16, 1979) of utility meter data and resident estimates of appliance usage for selected dwellings at four particular military bases,

c) Utilization of these data for the purpose of validating the norm calculation procedure.

The preparation of the norm pamphlet was independent of the latter two functions of this program, but it was sent to most of the field test participants in order to obtain feedback concerning its content, readability and overall effect. The principal outputs of the field test task are:

i) A norm pamphlet which is ready to be printed,

ii) A comprehensive energy requirements/consumption data base for the participating residences,

iii) A finalized and validated norm calculation procedure.

The field test task (Task 5) was divided into five subtasks:

5.a Norm Pamphlet (see Section 5.2)

5.b Field Test Program Plan

5.c Data Acquisition

5.d Data Evaluation

5.e Norm Evaluation and Finalization.

The second subtask, that of developing the Field Test Program Plan, was accomplished and is included as Appendix C. The sections below present a discussion of the implementation of the field test plan and the data analysis and evaluation completed to validate the norm procedure presented in Section 3.5.

4.2 SITE SELECTION

Several criteria were employed in selecting sites for use in the field test. First, because each participant had to have a full set of utility meters in order to evaluate consumption, the sites were chosen from among those participating in either the Family Housing Mock Utility Billing System (MUBS) or the Fixed Facility Energy Consumption Investigation. The latter of these two programs is a study being conducted by the U.S. Army Construction Engineering Research Laboratory (CERL) to identify energy consumption patterns at certain fixed Army facilities.

Since there was a greater variety of metered housing and compiled residence data available through the former program, and since the residents at these bases were already familiar with the basic concepts of a norm via the Mock Utility Billing System, it was decided that three bases should be selected from among those participating in the MUBS. One site was selected from among those involved with the Fixed Facility Energy Consumption Investigation because, while there were fewer dwellings from which to choose participants, these dwellings were equipped with instrumentation which recorded weather and energy consumption readings every hour throughout the entire day.

The four sites which were selected for use in the field test program are listed below along with the SAI point of contact for each base:

1. Fort Eustis, Virginia (Mr. Blaney Hill)
2. Great Lakes Naval Training Center, Illinois (Mr. A.L. Bradley, Ms. Pam Hughes, Ms. Sue Brooks)
3. Fort Hood, Texas (Mr. Mel Davis)
4. Point Mugu, California (Mr. Gene Graves)

Additional criteria were employed in selecting the particular bases which would participate. These criteria centered mainly on the climatic factors. It was desirable to achieve a diversity in climate among the sites chosen in order to fully test the space conditioning components of the norm calculation procedures. The chosen sites exhibit the following diverse climatic characteristics:

1. Fort Eustis, Virginia - significant space conditioning requirements in an environment near the Atlantic Ocean,

2. Great Lakes, Illinois - significant space conditioning requirements with weather strongly affected by Lake Michigan,

3. Fort Hood, Texas - very significant space cooling requirements in the summer, and it is in an inland environment,

4. Point Mugu, California - virtually no space conditioning requirements, and no air conditioning units are permitted on the base.

The choice of Point Mugu provided one site at which there would be no space conditioning component for the norm through the summer months of the field test program. This provided a site where the appliance portion of the norm could be validated without introducing the additional complicating factors having to do wtih space conditioning. Also, about half of the residences selected at Great Lakes did not have space cooling capabilities, making it possible to examine closely the effects of having or not having air conditioning among houses at the same site.

4.3 INSTRUMENTATION

Two types of instrumentation were employed for the field test - weather sensing/recording devices and utility metering equipment. The utility meters were already in place as a result of the Pilot Metering Program or the Fixed Facility Energy Consumption Investigation. The weather equipment was leased from the manufacturer, Weather Measure Corporation, and consisted of the following equipment:

i) Dry bulb temperature and dewpoint sensor and recording devices,

ii) Wind speed and direction sensing and recording devices,

iii) Solar pyranograph for measuring solar radiation on a horizontal surface.

This equipment was used only at Fort Eustis and Great Lakes. The CERL Fixed Facility Energy Consumption Investigation was used to provide the weather and energy consumption data at Fort Hood, and the base weather station provided SAI with weather data at Point Mugu. In order to supplement, evaluate and fill minor gaps in the SAI data, more weather data was collected from the Glenview Naval Air Station (Glenview, IL) and the Fort Eustis heliport.

For indoor temperature measurement, each participant with air conditioning capability was provided with an indoor thermometer from which to make twice daily temperature recordings in the largest room of the dwelling.

The relevant utility meters at the various sites were:

a) Fort Eustis - electricity (The other fuel in use at Fort Eustis is oil, and the oil supply is shut off in the cooling season),

b) Great Lakes NTC - electricity and natural gas,

c) Fort Hood - electricity and natural gas,

d) Point Mugu - electricity and natural gas.

4.4 DATA REQUIREMENTS

The data required from the field test activity falls into five major categories:

1. Site weather data,
2. Building characteristics,

3. Appliance data,

4. Human factors data, and

5. Energy consumption data.

The weather data was collected on a site-by-site basis, while the remaining four categories pertain to the individual households participating in the field test. Survey sheets used to collect initial residential and appliance data are presented in Appendix D.

4.4.1 Site Weather Data

Four weather-related quantities are required in the heating and cooling requirements portion of the norm evaluation:

a. Wind velocity and direction,

b. Dry bulb temperature,

c. Wet bulb temperature, and

d. Insolation.

Wherever possible, these quantities were used on the basis of their hourly values. Where that was infeasible, the daily maximum, minimum and average values will be employed in determining norm values.

4.4.2 Building Characteristics

These data again relate to the heating and cooling requirements portion of the norm in that they help determine what effect the weather factors have on the building's space conditioning loads. The information which was used to assess the building loads is:

(a) The building's construction materials,

(b) Building orientation (used with respect to insolation factors),

(c) Building configuration dimensions, and shading, and

(d) Insulation.

4.4.3 Appliance Data

In order to assess the energy consumption of appliances, it is necessary to know what types of appliances are in use. This is feasible only for the major household appliances. Those which were considered separately in the norm procedure evaluations were assessed according to nameplate information:

(a) Furnace
(b) Heat pump
(c) Air conditioner (central - there were no room AC's)
(d) Humidifier
(e) Water heater
(f) Refrigerator/freezer
(g) Dishwasher
(h) Clothes washer
(i) Clothes dryer
(j) Range
(k) Oven
(l) Television set

In addition, a measure of the building lighting was made. This consisted of collecting data on the wattage of the various light bulbs (both incandescent and fluorescent) and each light fixture's usage, general (e.g., room lights) or special (e.g., kitchen range light).

To supplement the water heater information, the hot and cold tap water supply temperatures were taken.

4.4.4 Human Factors

The human characteristics of a household will clearly influence the total energy consumption in a dwelling. Several of the most basic of these characteristics incorporated into the evaluation of the norm calculation procedures, including:

(a) Number of occupants

(b) Spouse employment status

(c) Hours of dwelling vacancy

4.4.5 Energy Consumption

Finally, actual and reported energy consumption data were required:

(a) Electrical consumption (meter)

(b) Oil or natural gas consumption (meter)

(c) Twice daily indoor temperature readings (taken in the dwelling's largest room)

(d) Appliance usage data (participant logging)

(e) Shower/bath usage data (participant logging)

The usage data were "close as possible" estimates of the daily usage patterns of the household, collected in order to correlate consumption estimates with actual energy consumption data.

4.5 PARTICIPANT SELECTION

Since participation in the field test was voluntary, the participants were taken from a list of candidates selected to provide an appropriate diversity in building and occupant

characteristics. The first necessary characteristic for each participant was that the family's residence be equipped with working electric and (if relevant) fossil fuel meters. After that, two other types of criteria were used. The first was that at least half of the field test participants should have air conditioning. Within that half, some variety in house type and number of occupants was desirable. "House type" will generally be characterized by the criteria which determine the Group 3 distinctions among the Group 1 houses of the Pilot Metering Program, e.g., construction material, location within a multiplexed unit, etc. Since the house type is less important for those units without space cooling capability, the criteria for this group were mainly those of obtaining diversity in family size and, to a lesser extent, house type.

As a result of these considerations, the selection of candidates at Point Mugu centered mostly on choosing families of several different sizes. Also, because of the small number of houses with recording devices on their utility meters at Fort Hood, all those with such instrumentation were solicited for participation, without regard to family size or house type. A brief summary of these characteristics for the field test participants is shown in Table 4.1.

The field test began with a total of 40 participants. One Great Lakes participant dropped out for personal reasons, and one family each moved away from Point Mugu and Fort Hood. Malfunctioning meter reading and recording devices at Fort Hood caused the loss of one unit. Thus, the field test ended with complete data for 36 residences and partial data for 2 residences as follows:

Table 4.1. Participating Households Listed by Base

FORT EUSTIS PARTICIPANTS

Field Test Unit No.	Building No.	Number of Occupants	Building Type	Space Cooling
1101	342B	5	2 Story, TWNHSE, Center (Brick)	CAC
1102	346B	4	"	"
1103	346C	5	"	"
1104	346D	4	"	"
1105	346E	5	"	"
1106	350B	4	"	"
1107	350D	4	2 Story, TWNHSE, End (Brick)	"
1108	2105A	4	1 Story Duplex (Brick)	"
1109	2105B	3	"	"
1110	2108A	2	"	"
1111	2122B	5	"	CAC

GREAT LAKES PARTICIPANTS

1201	1844B	5	2 Story, TWNHSE Split-Level (Frame)	None
1202	1846A	2	"	"
1203	1876B	4	"	"
1204	2130	4	1 Story, Single Family (Precast Concrete)	"
1205	2652A	5	2 Story, TWNHSE, End (Precast Concrete)	None
	4202A**	5	2 Story, TWNHSE, End (Frame)	CAC
1206	4205A	5	2 Story, TWNHSE, End (Frame)	"
1207	4211B	5	2 Story, TWNHSE, Center (Frame)	"
1208	4220C	5	2 Story, TWNHSE, Center (Frame)	"
1209	4221D	5	2 Story, TWNHSE, Center (Frame)	"
1210	4229D	5	2 Story, TWNHSE, End (Frame)	"
1211	4231C	5	2 Story, TWNHSE, Center (Frame)	CAC

**Dropped out of field test

Table 4.1. Participating Households Listed by Base (Cont'd)

FORT HOOD PARTICIPANTS

Field Test Unit No.	Building No.	Number of Occupants	Building Type	Space Cooling
1301	5669-2***	6	1 Story, Duplex (Frame)	CAC
1302	60062-1	4	"	"
1303	60062-2	7	"	"
1304	60100-1	4	"	"
1305	60100-2	5	"	"
1306	6443-1*	4	1 Story, Duplex (Frame)	"
1307	6809***	4	1 Story, Single Family (Frame)	CAC

POINT MUGU PARTICIPANTS

1401	1019	3	1 Story, Single Family (Frame)	None
1402	1174	5	"	"
1403	1180	5	"	"
1404	1182	4	"	"
1405	1208*	4	"	"
1406	1224	5	"	"
1407	1529	4	"	"
1408	1559	3	"	"
1409	1602	5	"	"
1410	1920A	7	1 Story Duplex (Frame)	"
1411	1990A	4	"	None

*Moved away during field test

***CERL equipment failure - no meter data

Fort Eustis - 11 participants

Great Lakes - 11 participants

Fort Hood - 4 participants (plus one partial)

Point Mugu - 10 participants (plus one partial)

The residences which participated in only part of the field test are starred in Table 4.1. The two Fort Hood duplexes for which there was complete data were master metered, so that utility meter readings were available only for the duplex as a whole. The data received from CERL for the remaining units at Fort Hood proved to be questionable. Conversations with CERL indicated that these units had unreliable meter data and had to be discarded. Some major characteristics of the field test participants and their residences are summarized in Table 4.2 and Table 4.3 below. These data include those people who participated in just a portion of the field test and those at Fort Hood who participated but whose meter reading/recording instruments failed.

4.6 PARTICIPANT ORIENTATION AND INITIAL DATA ACQUISITION

A two-member team of SAI personnel was assigned to each site, and these people were responsible for the participants' orientation and the initial phase of the data collection. (The one exception to this procedure was Fort Hood, where a single SAI representative handled the site.) During the week of July 9-14, 1979, each SAI team met with its on-base contact and finalized the logistics of the field test. This included:

1. Notification of the base residents of SAI's presence,
2. Selection of candidates for field test participation,

Table 4.2. Field Test Housing Characteristics, Occupancy and Ages

Characteristic		
Number of Units		40
Percent of Units with:	2 Bedrooms	30%
	3 Bedrooms	63
	4 Bedrooms	7
Total Number of Occupants in Field Test		176
Average Number of Occupants Per Unit		4.4
Average Number of Occupants Per Bedroom		1.36
Percent of Occupants in the Following Age Brackets:		
Less than 18 Years		56%
18 to 25		9
26 to 30		13
31 to 40		20
41 to 50		2
Average Age of Occupants under 18 Years		6.4

Table 4.3. Field Test Appliance Summary

Appliance Type and Number of Appliances in Living Unit, Where Applicable	Percent of Living Units Having Appliance (40 Units Total)
Refrigerators: 1	82
2	18
Freezer	36
Clothes Washer	90
Clothes Dryer: Gas	0
Electric	90
TV Sets: 0	2
1	67
2	24
3	7
Dishwasher	67
Microwave Oven	13
Central Air Conditioner	60
Window Air Conditioner	0

3. Interviewing candidates and finalizing participant selection,

4. Collecting resident information and data describing building characteristics, appliances and lighting (see Appendix D for sample survey sheets for this information), and

5. Making arrangements to obtain as-built plans for the various participants' dwellings, and arranging to obtain the appropriate Group 2 and Group 3 data sheets for all bases except Fort Hood.

During the initial interviews, each participant was apprised of his/her field test responsibilities, and these consisted of filling out a log sheet (a representative log booklet is presented in Appendix D) describing meter readings and appliance usage for each day of the field test. The purpose of the field test was discussed with each person at length and procedural questions were cleared up. Arrangements were made to pick up each week's log sheets (bound in a log booklet) and distribute the next week's booklet. Each participant signed an "agreement to participate" which detailed his/her responsibilities and clarified the payment procedure, which consisted of a fifty dollar payment at the end of each month of the field test. Finally, each participant was provided with the phone number of an on-base contact (usually the number of the SAI point of contact) to whom questions could be directed.

4.7 PARTICIPANT DATA LOGGING

The field test participants were asked to log the following data for each day of the field test:

a) Number of person meals served at breakfast, lunch and dinner,

b) Approximate total usage time of the kitchen range (range is ON if one or more burner[s] is on), the standard kitchen oven, the microwave oven (if applicable) and the television(s),

c) Number of uses of the dishwasher, clothes washer and clothes dryer (as applicable),

d) Total numbers of showers and baths,

e) Hours of house vacancy,

f) Air conditioner setback times and setback temperatures,

g) Twice daily temperature recordings from the dwelling's largest room,

h) Once-daily utility meter readings for the first two weeks of the field test at Fort Eustis, Great Lakes and Point Mugu.

A sample completed log booklet is shown in Appendix D. Although participants were asked to read their utility meters only during the first two weeks of the field test, most continued to do so throughout the field test. These readings were supplemented (and cross-checked) with meter readings taken by SAI personnel at the time of the weekly log booklet collection and distribution.

4.8 DATA ACQUISITION AND HANDLING

The data acquisition task consisted of gathering all information required to calculate and evaluate the norm. The data came from the following sources:

a) Site weather data

- SAI on-site weather stations (Great Lakes and Fort Eustis),
- Glenview (IL) Naval Air Station (Great Lakes),
- Fort Eustis heliport,
- CERL (Fort Hood),
- Point Mugu Weather Station,

b) Building characteristics
- As-built plans obtained directly from each base,
- Group 2 and Group 3 building survey data sheets obtained from the housing offices at Great Lakes and Point Mugu and from Utility Services at Fort Eustis,

c) Appliance data
- Interviews involving SAI staff members and field test participants,
- data from the American Home Appliance Manufacturers Association,
- telephone conversations with appliance manufacturers and retail appliance outlets,

d) Human factors data
- interviews involving SAI staff members and field test participants,

e) Estimated energy consumption data
- participant log sheets and residence visits made by SAI staff members.

The interviews between SAI personnel and the participants took place once before the start of the field test, once at the midpoint of the field test, and once at the end of the test. In addition, SAI personnel visited Fort Eustis, Great Lakes and Point Mugu once each week during the entire field test activity in order to exchange new log booklets for completed log booklets. Weather data recordings were also taken from the SAI equipment at Fort Eustis and Great Lakes at these times. The other weather data were obtained through visits to Glenview NAS and the Fort Eustis heliport, and through requests to CERL for Fort Hood weather data. The original test plan called for the use of weather data from CERL's weather equipment at Fort Hood. This equipment was later found to be out of order, so the actual source of Fort Hood weather data became the airport weather service offices at Austin and Waco. Fort Hood is located near and

between these cities, and it is felt that an average of the data from these two sites should suffice for the field test.

As the data was collected, it was examined for obvious errors, collated and placed in computer storage for later usage by the norm calculation procedures. Any obvious misunderstandings on the part of participants was thereby detected early and remedied through telephone or personal contact with the participants.

4.9 DATA ANALYSIS

The principal purpose of the data analysis and norm evaluation activity was to check the validity of the norm procedures discussed in Section 3 and, if necessary, make refinements to the norm. This was done according to the general approach which will now be described.

When the final form of the norm algorithm is set, there are numerous parameters which need to be set. For example, it must be decided which indoor temperature standards will be used in determining the allowable energy expenditures for space conditioning. Allowable amounts of hot water usage must also be determined, and the maximum temperature for this hot water must be decided upon. There are similar measures for allowable refrigerator kilowatt-hour usage, room lighting levels, etc. These standards are defined in terms of parameters which describe them, and it is these parameters along with the input data (weather, building characteristics, family size, etc.) which determine the overall calculated norm level.

However, rather than using these parameters to define a standard usage level, it is possible to give these parameters the

values which actually appear in a particular residence. For instance, if a family keeps its house at a constant 75°F, this temperature parameter value may be used in the procedures which determine the amount of energy used for space cooling. If a residence uses hot water at 160°F (instead of a more reasonable 140°F), this value of this parameter may be used. If the other norm parameters are set to reflect such actual conditions (instead of "standard" or "norm" conditions), the norm calculation procedure should give a total energy consumption figure which approximates the actual energy consumption of the individual household over the billing period under consideration.

The following approach was therefore used to validate the norm calculation procedure. To the maximum extent practical, the norm parameters (with the exception of indoor temperature which was not always properly recorded) were set to reflect the actual reported conditions in each household participating in the field test. Because of the wide variation in the completeness of the temperature information provided by the participants, a nominal indoor temperature of 78°F was used for all cases for two time periods - a period of one week and a period of four weeks. Then, the log booklet data from a few of the most reliable participants was used to examine the effect of using the reported indoor temperatures instead of the standard 78°F. The predicted usage level resulting from the calculations was compared to the actual usage level as determined through the meter readings. Comparison of these results provided some measure of the validity of the norm calculation procedures.

There are some difficulties intrinsic to this approach, but it was felt that such problems would not critically impair the validity of this evaluation approach. These difficulties include:

a) Due to age or poor maintenance, appliances may not operate with the efficiency indicated by the manufacturers' ratings.

b) It is difficult to assess many aspects of a residence's construction quality even when the as-built plans are available, due in large part to variations in the quality of construction and upkeep.

c) The norm calculation procedures work on a daily basis, but the meters could not be read at 12 midnight. Therefore, the meter readings which were used will necessarily introduce a small error into the evaluation process.

d) It is impossible to incorporate all existing site specific variables into a norm calculation procedure, i.e. infiltration. Not only would the computer execution time of such a procedure by prohibitive, but many of the variables would be difficult or impossible to quantify. In addition, the actual implementation of a norm calculation procedure with that level of detail would involve a data collection cost which far exceeded the energy cost savings to the military.

With these and other related complexities of consumption estimation in mind, the evaluation of the norm should be done with two considerations in the forefront. First, the above points confirm that there will be a standard variation between actual and predicted energy usage. It would be hoped that this variation will be relatively small in most cases, but there were cases in which it was unacceptably large. The second consideration is therefore the use of the participants' log booklet information to attempt to explain any such large variations. For example, energy consumption can be expected to make a significant jump when a substantial amount of entertaining is done. Obviously, a norm calculation procedure is not going to have a component which requires specification of the exact number of meals cooked each day or the number of people present in the dwelling at all times. However, such considerations may pile up and have a

significant effect on consumption. Log booklet data can sometimes be used to explain such aberrations. These considerations are discussed below in reference to the actual field test results.

The tables which follow present the results of the norm calculation comparisons of total energy consumed based on procedure evaluations. The data showing the breakdown of energy by fuel type is presented in Appendix F. Table 4.4 presents the results for a four-week test period for each site. Table 4.5 does the same for a one-week test period. Table 4.6 shows the slightly different results obtained for Fort Eustis and Great Lakes when the reported indoor temperatures were used instead of the standard 78°F.

There are several observations to be made concerning Tables 4.4 - 4.6. The first is that the norm procedure estimates were generally low. In fact, 81.8%, 75.8% and 72.7% of the estimates in Tables 4.4, 4.5 and 4.6 were low, and the mean percent variations encountered were

	Fort Eustis	Great Lakes	Point Mugu
Table 4.4	-10.6% (16.7)	-11.0% (15.1)	-11.9% (16.8)
Table 4.5	-13.1% (22.7)	-5.5% (18.4)	-10.1% (19.9)
Table 4.6	-15.2% (13.2)	-5.5% (14.9)	---

while the mean magnitudes of the percent variations were

Table 4.4. Comparison of Calculated and Actual Energy Consumption for a Four-Week Period

FORT EUSTIS

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1101	6.26	5.36	16.8%
1102	5.83	5.14	13.4
1103	6.39	7.69	-16.9
1104	5.27	5.54	- 4.9
1105	5.83	6.68	-12.6
1106	5.51	7.59	-27.5
1107	6.13	6.40	- 4.2
1108	4.67	8.44	-44.7
1109	4.60	5.11	-10.0
1110	4.24	4.41	- 3.9
1111	6.33	8.15	-22.4

GREAT LAKES

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1201	5.08	6.17	-17.7%
1202	3.05	5.04	-39.6
1203	5.55	5.38	3.1
1204	4.85	6.17	-21.3
1205	5.28	6.05	-12.7
1206	7.07	8.60	-17.8
1207	7.74	8.62	-10.2
1208	7.11	5.77	23.2
1209	7.67	8.91	-13.9
1210	7.04	7.11	- 0.9
1211	6.64	7.63	-13.0

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table 4.4. Comparison of Calculated and Actual Energy Consumption for a Four-Week Period (Cont'd)

POINT MUGU

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1401	4.26	4.03	5.7%
1402	4.49	5.59	-19.6
1403	5.36	6.37	-15.7
1404	4.12	5.13	-19.7
1405	4.81	5.20	- 7.5
1406	5.16	5.47	- 5.7
1407	4.84	4.96	- 2.5
1408	2.59	2.35	10.3
1409	5.09	5.43	- 6.3
1410	5.10	8.96	-43.1
1411	4.18	4.80	-12.9

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table 4.5. Comparison of Calculated and Actual Energy Consumption for a One-Week Period

FORT EUSTIS

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1101	1.57	1.16	36.0%
1102	1.48	1.26	18.2
1103	1.61	1.91	-15.8
1104	1.32	1.51	-12.2
1105	1.48	1.75	-15.4
1106	1.40	2.10	-33.4
1107	1.55	2.10	-25.9
1108	1.19	2.32	-48.7
1109	1.17	1.29	- 9.0
1110	1.07	1.15	- 6.3
1111	1.62	2.35	-31.4

GREAT LAKES

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1201	1.25	1.31	- 4.6%
1202	0.75	1.03	-27.7
1203	1.36	1.67	-18.5
1204	1.19	1.39	-14.4
1205	1.30	1.06	22.5
1206	1.64	1.51	9.0
1207	1.75	2.11	-16.8
1208	1.66	1.21	37.3
1209	1.74	1.69	3.3
1210	1.61	1.47	9.4
1211	1.53	1.62	- 5.6

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table 4.5. Comparison of Calculated and Actual Energy Consumption for a One-Week Period (Cont'd)

POINT MUGU

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1401	1.04	1.07	- 2.3%
1402	1.09	1.16	- 5.7
1403	1.23	1.46	-15.9
1404	1.00	1.32	-24.6
1405	1.17	1.22	- 4.2
1406	1.26	1.38	- 8.6
1407	1.20	1.39	-13.5
1408	0.63	0.51	24.1
1409	1.15	1.24	- 7.3
1410	1.23	2.53	-51.3
1411	1.02	1.10	- 7.2

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table 4.6. Comparison of Calculated and Actual Energy Consumption for a One-Week Period Using Recorded Indoor Temperatures

FORT EUSTIS

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1101	1.16	1.16	0.3%
1102	1.04	1.26	-16.8
1103	1.58	1.91	-17.5
1104	1.41	1.51	- 6.3
1105	1.31	1.75	-25.3
1106	1.42	2.10	-32.5
1107	1.65	2.10	-21.2
1108	--	2.32	--
1109	1.23	1.29	- 4.4
1110	1.22	1.15	6.8
1111	1.54	2.35	-34.7

GREAT LAKES

1201	1.25	1.31	- 4.6%
1202	0.75	1.03	-27.7
1203	1.36	1.67	-18.5
1204	1.19	1.39	-14.4
1205	1.30	1.06	22.5
1206	1.70	1.51	12.8
1207	1.81	2.11	-14.0
1208	1.62	1.21	34.2
1209	1.73	1.69	2.3
1210	1.47	1.47	- 0.4
1211	1.60	1.62	- 1.1

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

	Fort Eustis	Great Lakes	Point Mugu
Table 4.4	16.1% (11.5)	15.8% (10.0)	14.8% (14.4)
Table 4.5	22.9% (12.6)	15.3% (10.1)	16.0% (16.5)
Table 4.6	16.6% (11.4)	10.8% (11.8)	---

The numbers in parentheses above are the corresponding standard deviations. That is, for percent variations $V_1,\ldots,V_n$, the mean percent variation is

$$\bar{V} = \frac{1}{n} \sum_{i=1}^{n} V_i$$

and standard deviation is

$$\frac{1}{n} \sum (V_i-\bar{V})^2$$

Similarly for the magnitudes $|V_i|$. These results are not unexpected because of the "norm" nature of the calculation procedures. Not every characteristic of the individual participants could be modeled according to actual conditions. Some assumptions had to be made. For example, day to day occupancies were assumed constant, meaning that day trips or short term visitors were not accounted for by the calculations. Indeed, these were not always reported in sufficient detail by the participants. Such assumptions will virtually guarantee some variation between the estimates and actual consumption. When combined with some statistics which indicate that occupants of military family housing are probably overconsuming, both the magnitude of the variations and the underestimating character of the estimates are to be expected.

A second observation is that there were some instances in which the variation between the estimates and the actual consumption was relatively large. There were only two cases (Table 4.5, Unit 1101 and Tables 4.4, 4.6, Unit 1208) in which consumption was overestimated by more than 30%. Some of this overestimate may be accounted for by the fact that Unit 1101 used very little air conditioning during that week even though outdoor temperatures (and the usages of the other participants) indicated that significantly more space cooling would have been reasonable. Table 4.6 shows that, when this is taken into account, the variation is reduced to 0.3%. The revised estimate for Unit 1208 in Table 4.6 does not show such a significant improvement (37.3% to 34.2%). One reason for this may be that this participant did not complete the log books in such a way as to clearly indicate air conditioner usage. It is known that, for health reasons, this house is kept warmer than normal, but it was not possible to tell whether the air conditioner was turned off or merely set back to 80°F. If it had been turned off, the revised estimate would have shown an 11% variation between the estimate and actual consumption, due mainly to a rather small actual hot water usage in that unit.

The more common occurence was significant underestimation of actual consumption. As discussed above, frequent underestimation is to be expected. Those cases in which the underestimate was more than -30% were

Table 4.4	Unit	1108 (-44.7%)
		1202 (-39.6%)
		1410 (-43.1%)
Table 4.5	Unit	1106 (-33.4%)
		1108 (-48.7%)
		1111 (-31.4%)
		1410 (-51.3%)
Table 4.6	Unit	1106 (-32.5%)
		1111 (-34.7%)

The discrepancies regarding 1108 cannot be resolved because of the low quality of the data provided by the participant. Unit 1108 may have entertained extensively since an officer resides there, but that is a conjecture. Unit 1106 generally consumed more than was estimated (variation -27.5% in Table 4.4), but the log booklet information provided by that unit indicated nothing unusual in the reported usage patterns. Unit 1111 also consumed energy in unusually large amounts as compared to other similar units/families at Fort Eustis, but there was again nothing in the log booklet information which would account for such a discrepancy. The main cause of the underestimates for Unit 1202 was in hot water usage, where the usage was double the estimates. This was not expected because only two people live in that unit, yet their consumption of natural gas is about that of most families of five at Great Lakes. This discrepancy must therefore be attributed to significant overconsumption or a faulty natural gas meter. The natural gas consumption of Unit 1410 at Point Mugu more than doubled the estimates made, and nearly doubled the next highest natural gas consumption among the Point Mugu residents. The participant log sheets revealed no cause for such consumption, and it can only be conjectured that either the meter is malfunctioning or an unknown natural gas use is being made.

Finally, Tables 4.5 and 4.6 illustrate the consequences of changing a "norm aspect" of the calculation procedures to more closely model actual behavior. When the participants' reported indoor temperatures and air conditioner usages were employed in the calculation procedures, improved estimates were made possible in 11 of the 16 cases in which sufficient data was supplied. An "improved estimate" means that the magnitude of the percent variation is reduced. Of the five cases in which this magnitude was increased, three were underestimates which were revised to even lower estimates, one was an overestimate which increased, and one was an underestimate which increased to an even greater overestimate.

5. IMPLEMENTATION ASSESSMENTS

During the course of the development of the norm algorithm several decisions were made with regard to accuracy, computer time and input data requirements which were discussed in Section 3. In addition to these considerations, there remains a number of activities to be completed before a fully operational norm algorithm is valuable to the overall billing program.

A pamphlet explaining the operation of the norm along with some energy conservation tips has been prepared. It is expected that this will aid in the overall implementation of the billing program by informing those it impacts with an easy to read clear definition of the norm. Consideration has also been given to the implementation of a very simplistic norm which may accomplish the basic intent of the program

5.1 THE BILLING ALGORITHM

The previous sections have dealt with the technical issues of producing a norm algorithm that can be used with reasonable confidence. The result has been several computer programs and data files, which, when executed in the proper sequence, can calculate the norm energy consumption of a house and occupants. It is next necessary to fit this methodology in the overall process of computing the energy consumption bills.

The following paragraphs describe how an operational billing system based on the norm algorithm discussed in the previous sections would function. This description does not imply that all of the elements are operational, but reflects a realistic approach.

The operation of the whole billing process is shown schematically in Figure 5.1. There are basically three elements in the billing process:

- o Administrative Changes and Data Base Modifications
- o Processing of Measured Data
- o Calculation of Energy Norm and Bills

The first element deals with administrative data and consists of the adquisition and classification of data which is not routinely entered in the system. The routine data are the measured energy consumptions and meteorological variables. Administrative data thus would include such items as:

- o New family moving into a house
- o An increase or decrease in the number of occupants in the building
- o Building improvements and modifications
- o Readjustment of data found to be incorrect
- o Circumstances warranting special exceptions
- o Changes in norm criteria
- o New buildings
- o Length of billing period

This information is generally collected via telephone conversations, personal communications, written letters, notifications, etc. and has to be sorted and reduced in the form required by the system. This information would normally be entered immediately in the raw data base. The pre-processed data base, which results from running a computer program that has as input the raw data base, may be created at the end of the day or any other suitable

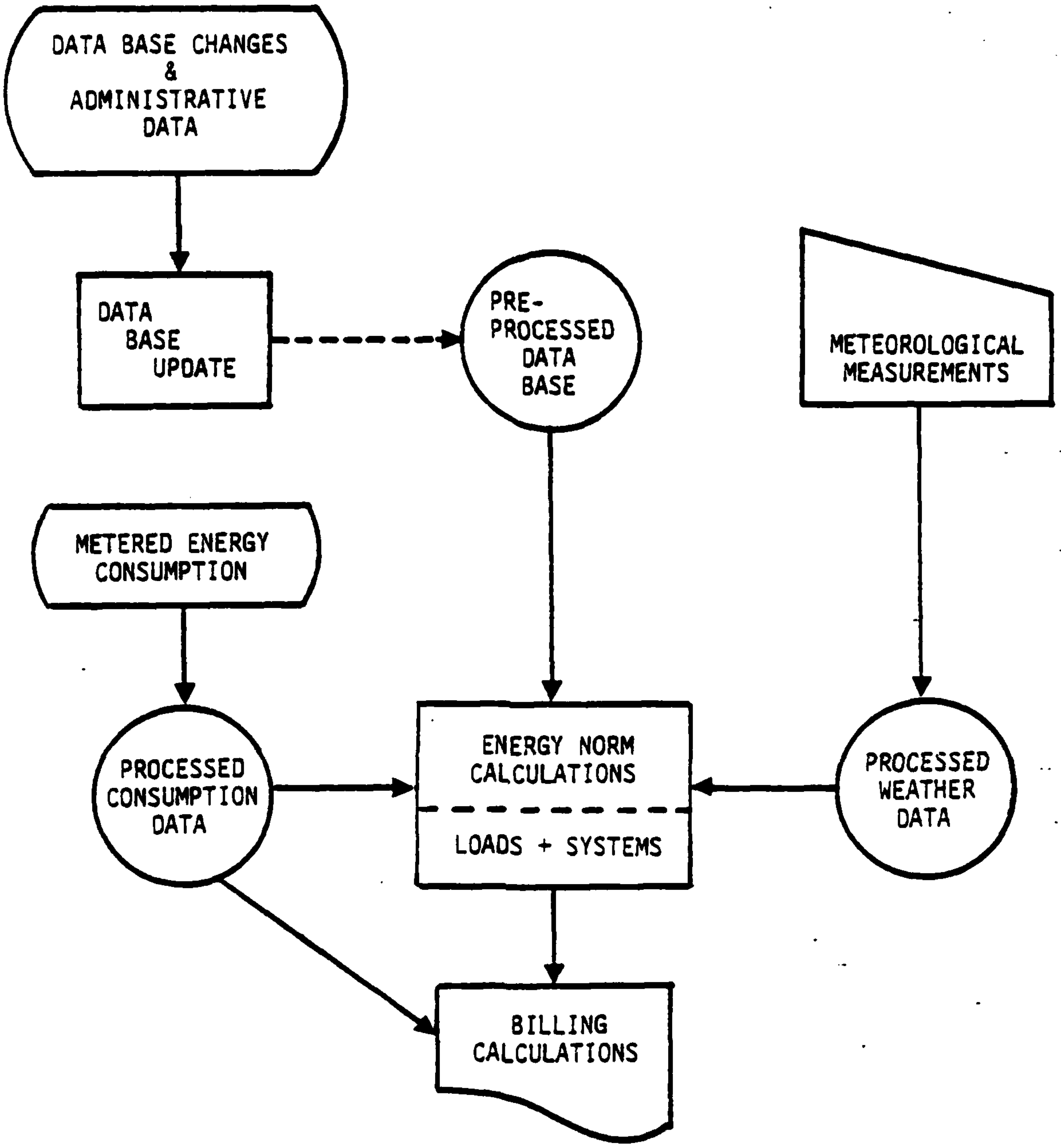

Figure 5.1. Functional Blocks of the Billing Procedure

time period. These parts of the billing process are shown in Figure 5.1 in the upper left hand side.

The second element consists of processing data that is acquired on a regular basis either manually or automatically. Manual data would generally be the meter readings that show the actual energy consumptions. This data is obtained by meter readers at each building who would record the data on a log sheet. This data is transferred into the computer and made part of the processed consumption data base. From this data, billing periods are determined and fuel consumption monitored. The data envisioned to be acquired automatically are the weather data, although a manual acquisition system could also be devised. The meteorological measurements are recorded and transmitted to the computer site where it is processed and reduced to a form suitable for the norm calculation. This data processing phase would have to be performed each time the billing calculations are required. Thus the measured data could be accumulated over a period of time before actually undergoing any processing. These two data bases, the energy consumption data and the processed weather data are shown on the left and right hand sides respectively of Figure 5.1.

All necessary data are now available to compute the norm for each of the buildings in the billing system. The SABLE program does this using the preprocessed data base and the processed weather data as inputs. The result of the norm calculations are allowable or normal energy consumption by fuel type. It should be emphasized that the output from the norm is an allowable or expected energy consumption quantity based on the weather, the type of house, and the family occupying it, and not the expected consumption.

The final step is to compute the "bill" that goes to the consumer. Any energy consumed in excess of that predicted by the norm is presumably charged to the consumer for which he thus has to pay at an equitable rate. The situation of him consuming less than predicted by the norm can be handled in three ways: (a) it can be ignored; (b) the consumer can be credited with the difference between norm and acutal consumption which he would use in the future to offset those situations where he consumes in excess of the norm; (c) the consumer is given a monetary allowance, or reward, proportional to the amount of energy saved. Other ways of handling can be thought of, but the actual procedure used is a policy question and not part of the present work.

The description given above can be summarized as follows: changes in the data base are made and the data base is updated, energy consumption data and meteorological measurements are collected and processed, energy norm calculations are performed, and the billing calculations executed. The process can be implemented in principle and no major obstacles are envisioned. There are questions that have to be resolved before implementing such a system that deal with the most cost effective way of accomplishing the above. For example, should there be one central facility or separate facilities each serving a site or region? How many people are required to (a) implement the procedure (a fair amount of initial data collection is required) and (b) to operate the system? What kind of training is required? How are grievances dealt with?

Although the data requirements of the present norm are very similar to those for the SAI norm, additional data will be required for the implementation of the SAI norm, which is somewhat more complex than the present norm and will therefore require additional software and greater computer storage and operating time.

The following additional data is required for implementation of the SAI norm: (1) orientation, shading and exterior color of buildings; (2) an inventory of household appliances; (3) information about the occupants such as their age, work patterns, etc.; (4) solar insolation and wind speed measurements.

Due to these additional data requirements, an initial on-site inspection of every housing unit will be required in order to obtain the necessary data. Provision must also be made to update information pertaining to the appliances as well as physical improvements/changes to the buildings. Occupancy related data will have to be changed with new tenancy or changes in the number of occupants or other occupancy related inputs. Additional instrumentation will have to be employed to collect solar insolation and wind speed data.

The mock billing system user manual will require revision and changes in existing forms in order to accomodate these additional data requirements. Before a billing procedure can be fully implemented, there are several issues which must be addressed:

- o Decisions must be made regarding which energy consuming devices are "allowable" as part of the norm.
- o It must be decided if the norm will be treated as a single value wherein any excess usage above that value is billed to the consumer, or whether some deviation from the norm will be allowed.
- o Decisions relating to the form of accounting must also be made so that the norm can be fairly applied over a period of time. For example, will credit be given for using less than the norm during any one period?

- The degree of centralization of the billing system must be decided; there could be one central billing center, regional centers could be established, or individual installations could handle their own billing requirements.
- Some procedure must be established to accomodate "special stations" and to hear appeals from tenants regarding their norm allocations or their energy consumption.
- Steps must be taken to educate housing maintenance people so that they understand and respond to requests for repairs and other services which have an impact on housing energy consumption.
- Housing occupants must be educated in energy conservation techniques.
- The entire system should be put through a check out or burn in period of at least one year prior to implementation.

5.2 NORM PAMPHLET

The norm pamphlet is a short, picture-oriented brochure to introduce military housing occupants to the use of the energy consumption norm. The body of the pamphlet addresses what goes into the calculation of the norm and how the norm will affect housing occupants.

The norm pamphlet would be an integral part of the implementation of the energy use norm. The target audience of the final form of this pamphlet is all military housing occupants to which the "norm" would be applicable. Energy efficiency information concerning the specific elements of the norm is presented as a guide to the occupant in meeting the "norm." The "why" of the norm will point out the positive aspects of energy conservation and the Congressionally-mandated need to reduce energy consumption in military housing. It will also point out the fairness of the "norm" concept.

The final version of the pamphlet is shown in Appendix E. The final draft shown in Appendix E is not the color version of the pamphlet because the color overlays required for a camera-ready pamphlet do not reproduce in the photocopy process. Several earlier versions of the pamphlet had been circulated among the SAI staff and the Navy in order to collect useful criticisms. These comments were incorporated into the final draft in Appendix E. The next-to-final draft was circulated to those field test participants familiar with the Family Housing Mock Billing Progam, and their comments and suggestions were also incorporated into the final draft of the pamphlet.

The main emphasis of the norm pamphlet were as follows:

1. Describing the importance of residential energy consumption as a major component of total national energy consumption,
2. Outlining the Congressional mandate for implementation of a norm concept,
3. Explaining the concept, development and implementation of the norm, with an emphasis on the norm being fair and unique to each family's situation,
4. Listing a small but useful collection of energy conservation hints for the household, with an emphasis on how these hints can help occupants of family housing reduce their consumption and meet their norm.

5.3 AN ALTERNATIVE USE OF THE NORM

The norm billing process as currently visualized calculates energy use on a regular basis, say 4 to 5 week intervals, using real-time weather. This process tends to be relatively complex and subjected to fluctuations in calculated energy consumption because of the relatively short time period

involved. If longer term average data could be used, then the reliability of the calculated numbers can be improved. The energy norm as developed in this report would still have to be used, but in a different mode.

Using historical weather data, the norm could be used to predict a seasonal allowance for energy, which could be paid to the occupants of the residence ahead of time. The actual weather data is tracked and at the end of the season, a true norm would be computed. If the norm were higher than previously predicted, additional compensation could be allowed to the occupants. If the new norm would be less, then any differences would not be refunded, but could be used by the occupants as they please or possibly be used for energy conservation improvements. The energy consumption would be measured and billed as in the private sector. Figure 5.2 shows a diagram of this concept. The advantages of this procedure are that it provides an incentive for the occupant to conserve, because anything less than the norm is cash in the pocket. Furthermore, the norm calculation should be more accurate and the actual work in preparing bills is not as subjected to time constraints as the monthly billing process. An additional advantage is that the computational effort is more efficient and therefore, less expensive. We can see no major disadvantages to this concept.

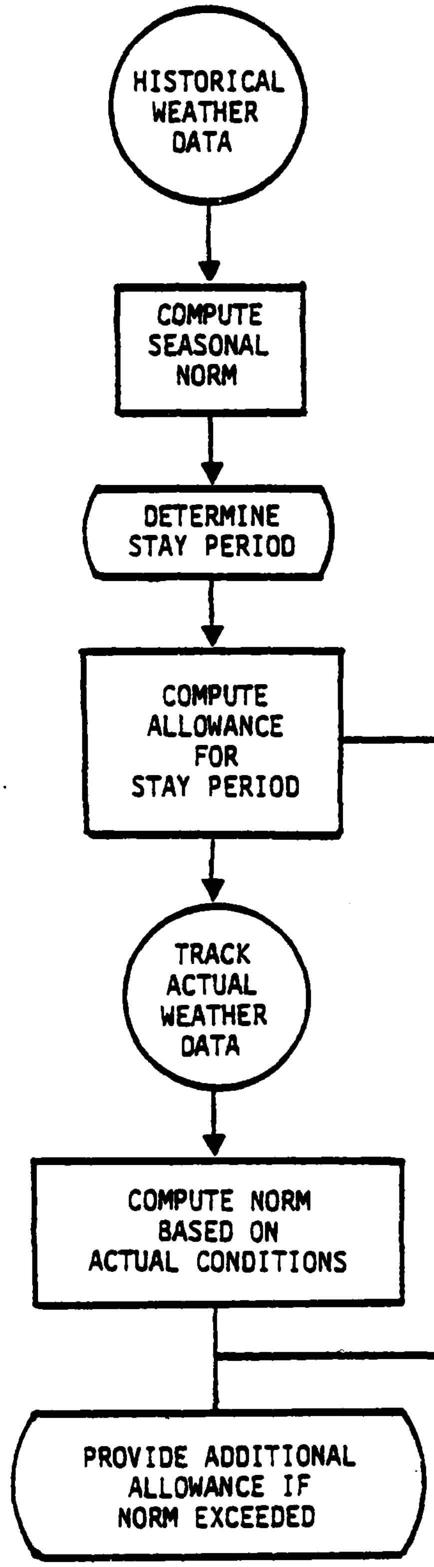

Figure 5.2. Alternative Use of the Norm Procedure

6. SUPPLEMENTARY ANALYSES

The requirement for instituting the norm impact came about because it was assumed that persons living in housing with energy supplied by the Department of Defense use more energy than their counterparts living in the civilian sector. A comparison was made in this project of the energy consumption in a group of military residential units at Port Hueneme, California and a group of civilian townhouses near the base.

In addition, the modified HEAP program was used to assess the energy savings potential of certain energy conservation improvements to typical residential units in three different climatic regions.

6.1 GOVERNMENT VERSUS PRIVATE USAGE

The objective of this task was to compare the energy consumption in the military residential sector with consumption in the civilian sector under the same climatic conditions. Occupants of military residences do not pay for energy usage, while occupants of civilian residences generally do pay for usage.

As a background to this comparison, a literature review was undertaken of the civilian sector where multifamily residential building energy consumption was determined with master meters and/or with individual meters at each dwelling unit.

A comprehensive analysis and review was made by Booz, Allen and Hamilton[49] of multifamily residential buildings which were converted from master meters to individual meters. A summary of these results is presented in Table 6.1.

Table 6.1. Conservation in Buildings Converted from Master Meters to Individual Meters at Each Dwelling Unit - Booz, Allen and Hamilton Results (Reference 49)

CASE STUDY	ENERGY	PERCENTAGE DECREASE IN ENERGY CONSUMPTION
ELECTRIC POWER RESEARCH INSTITUTE CASES FOR ELECTRICITY		
Houston Light & Power Co.	E	10.8
Arkansas Power & Light Co.	E	13.1
Baltimore Gas & Electric Co.	E	25.0
Cincinnati Gas & Electric Co.	E	36.0
Atlantic City Electric Co.	E	35.0
Dept. of Water & Power (L.A.)	E	16.6
Rochester Gas & Electric Co.		
Case 1	E	8.1
Case 2	E	4.2
Pacific Gas & Electric Co.		
Case 1	E	16.3
Case 2	E	20.6
Case 3	E	21.[illegible]
Case 4	E	21.4
Case 5	E	22.4
Case 6	E	18.2
Case 7	E	14.6
Case 8	E	13.9
Case 9	E	22.3
Case 10	E	17.8
Case 11	E	16.0
Pennsylvania Power & Light Co.	E	14.5
PLYMOUTH WOODS CONDOMINIUM ASSOCIATION FOR ELECTRICITY		
Townhouses converted	E	19.0
Apartments converted	E	27.0
RESIDENTIAL UTILITY BILLING SYSTEM		
Atlanta Case Studies		
Case 1	E	1.0
Case 2	E	11.0
Dallas Case Studies		
Case 1	E	8.0
Case 2	NG	15.0
Case 3	E	6.0
Case 4	NG	7.0
Case 5	E	8.0
Case 6	E	9.0
Case 7	E	10.0
Case 8	E	6.0
Charlotte Case Study	E	4.0 (9 in summer)
NORTHERN ILLINOIS GAS CASE STUDY		
Case 1	NG	7.0
Case 2	NG	5.0
ATLANTA GAS CASE STUDY		
Case 1	NG	6.0
BOOZ, ALLEN CASE STUDIES		
Case 1	E	25.0
Case 2	E	20.0
Case 3	E	26.0
Case 4	NG	-3.0
Case 5	NG	-8.0

NG = Natural Gas
E = Electricity

Booz, Allen and Hamilton concluded that individual metering of residential units results in electric savings of 15 to 20 percent. For natural gas, an investigation of buildings with meter conversions showed energy savings of 5, 6 and 7 percent for three conversions and energy increases of 3 and 8 percent for two conversions. It was hypothesized by the authors that these relatively low savings were linked to the low price of natural gas.

Matched pairs of master metered and individual metered buildings in the civilian sector were compared by Gross et al(50) based on five factors:

- o Geographic location
- o Physical attributes of the building affecting heat loss and the extent of public use areas
- o Heating, ventilation and air conditioning systems and water heating systems
- o Occupant status: singles and young marrieds, families with children, and elderly

Also included in the study was a modification of this matched pair technique using units which were converted from master meters to individual meters.

Gross et al found that residential customers whose electric service is provided through individual meters and who pay for this service consume about 26% less electric energy than those who receive service through a master meter.

For this task, energy consumption in the military and civilian residential sectors was studied at the Navy Construction Battalion Center at Point Hueneme, California and at adjacent civilian housing at Oxnard, California.

6.1.1 Military Sector Residences, Occupants and Appliances

A total of twenty military dwellings were used in the analysis. These dwellings, constructed starting in 1962, were single family, single story units built with floors of concrete slab on grade (S.O.G.). The dwellings were of frame and stucco construction, with asphalt shingle or crushed rock roofs. Some dwellings had wood or stone trim. All dwellings had four inches of loose fiberglass fill thermal insulation on the ceilings and one inch of fiberglass duct insulation on all furnace ducts. There was no wall insulation. Windows were of aluminum frame, some with sliding panels, and some with louvered windows.

The dwellings were duplexes built as mirror-image pairs, usually with a common wall in the garage to the adjacent unit. A total of four different building plans were involved. A plan and elevation for a typical military dwelling are presented in Figure 6.1 and 6.2.

Structural and thermal data was obtained from as-built drawings and from an on-site survey of each dwelling. This data was input to the HEAP computer program to obtain dwelling heat load requirements.

All residences had a forced air natural gas furnace with standby pilot light rated at 90,000 Btuh input and 72,000 Btuh output. The dwellings had a 40 gallon natural gas water heater with standby pilot light, rated at 48,000 Btuh input and 40.3 gallons per hour recovery at 100°F temperature rise.

Dwelling and occupant data for the military residences is presented in Table 6.2. Occupants ranged between two and six, and the average number of occupants per dwelling was 4.4. The

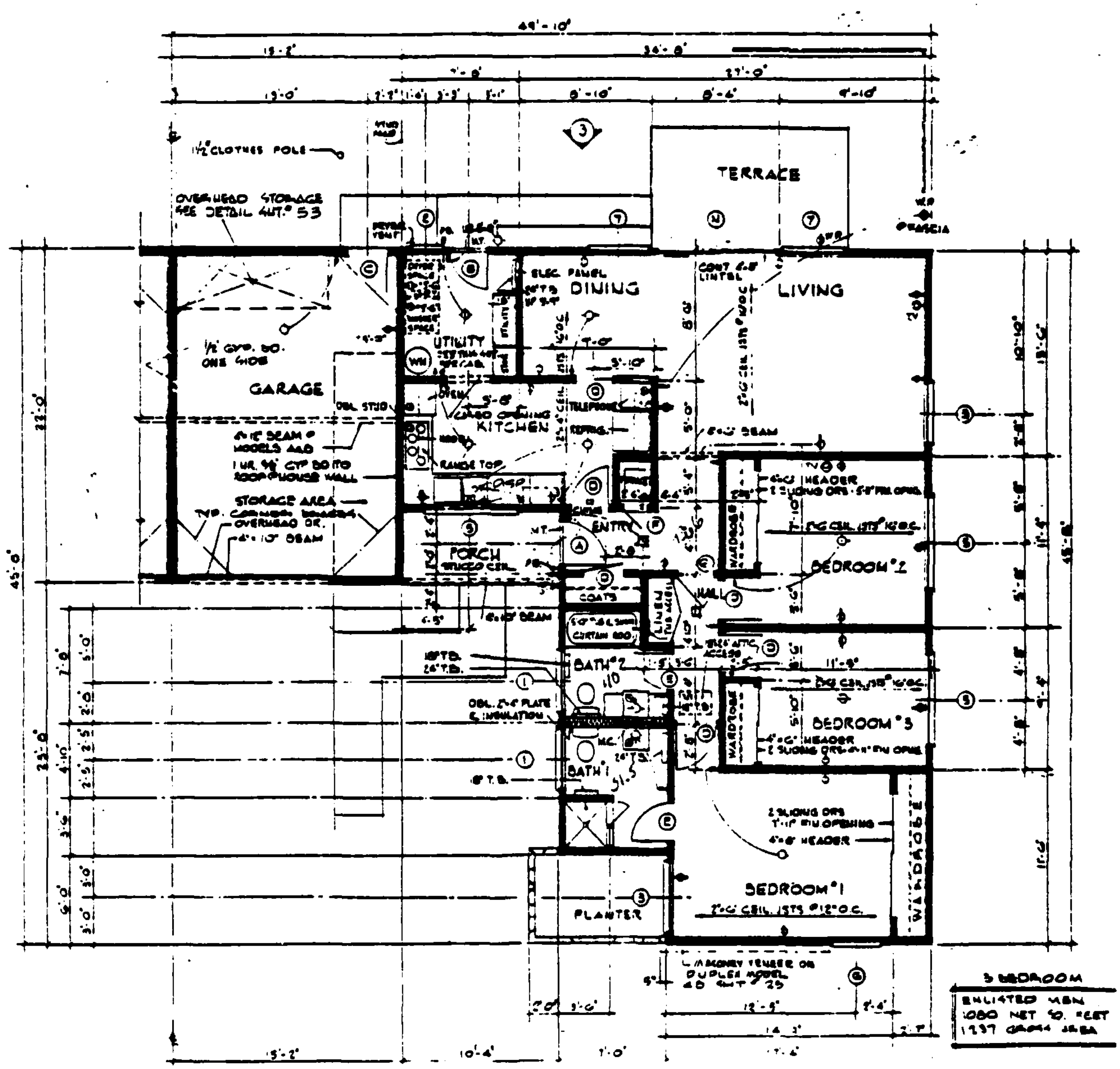

Figure 6.1. Plan of Typical Military Dwelling

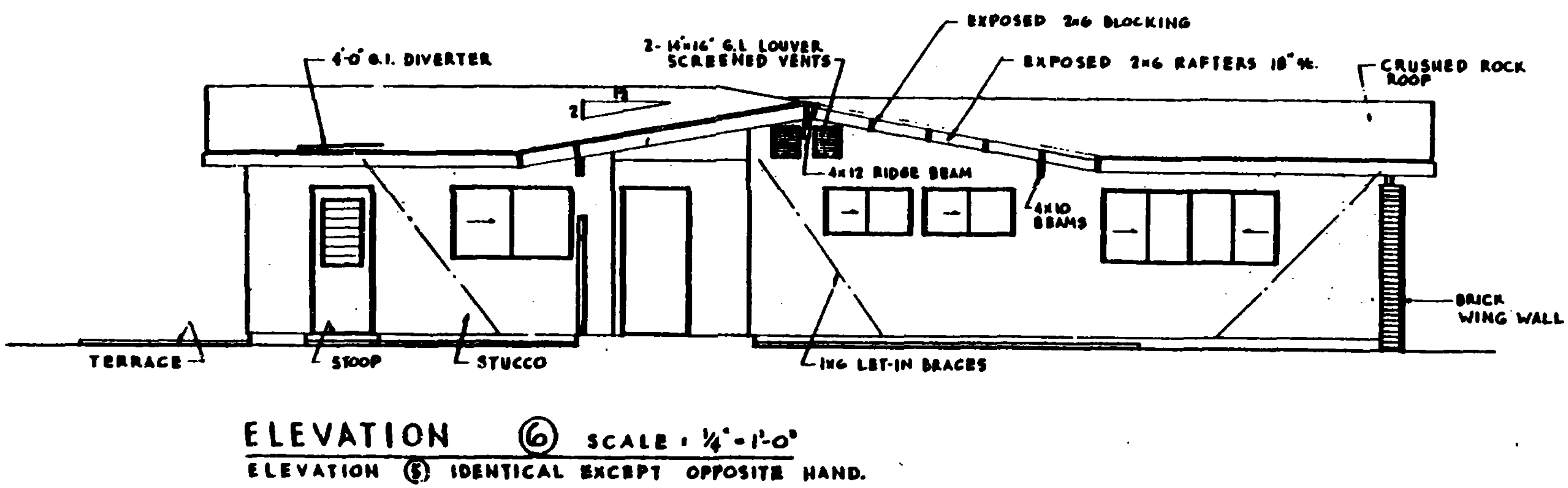

Figure 6.2. Elevation of Typical Military Dwelling

Table 6.2. Dwelling and Occupant Data for Military Residences

DWELLING NUMBER	LOCATION	NO. OCCUP.	NO. BEDROOMS	PLAN NO.	FLOOR AREA	WALL INSUL.	FLOOR	ATTIC
2	PT HUENEME	5	4	4	1321	NO	S.O.C.	YES
3	PT HUENEME	4	3	3	1165	NO	S.O.C.	YES
4	PT HUENEME	4	3	2	1174	NO	S.O.C.	YES
6	PT HUENEME	6	4	4	1321	NO	S.O.C.	YES
7	PT HUENEME	5	3	3	1165	NO	S.O.C.	YES
8	PT HUENEME	4	3	1	1268	NO	S.O.C.	YES
9	PT HUENEME	5	3	1	1268	NO	S.O.C.	YES
10	PT HUENEME	6	3	2	1174	NO	S.O.C.	YES
11	PT HUENEME	2	3	3	1165	NO	S.O.C.	YES
12	PT HUENEME	4	3	3	1165	NO	S.O.C.	YES
13	PT HUENEME	3	3	1	1268	NO	S.O.C.	YES
14	PT HUENEME	5	3	1	1268	NO	S.O.C.	YES
16	PT HUENEME	3	3	1	1268	NO	S.O.C.	YES
18	PT HUENEME	3	3	1	1268	NO	S.O.C.	YES
20	PT HUENEME	5	4	4	1321	NO	S.O.C.	YES
21	PT HUENEME	6	3	1	1268	NO	S.O.C.	YES
24	PT HUENEME	5	3	3	1165	NO	S.O.C.	YES
25	PT HUENEME	6	3	2	1174	NO	S.O.C.	YES
28	PT HUENEME	3	3	1	1268	NO	S.O.C.	YES
29	PT HUENEME	4	4	4	1321	NO	S.O.C.	YES
AVERAGES PER DWELLING		4.4	3.2		1239			

AVERAGE OCCUPANT PER BEDROOM: 1.38

dwellings had three or four bedrooms, and there were an average of 1.38 occupants per bedroom. Floor areas ranged between 1165 and 1321 square feet and the average was 1239 square feet.

Detailed occupant data is presented in Table 6.3. Fifty-one percent of the occupants were adults and 36% were in the 31 to 40 year age bracket. The average age of children was 10 years.

Data on appliances in military residences is presented in Table 6.4, as obtained from the on-site survey. All dwellings had a clothes washer and dryer, and all but three dryers were electric heated. Eight dwellings had two refrigerators. Thus, the average number of refrigerators per dwelling was 1.4. There were 1.4 televisions per dwelling.

6.1.2 Civilian Sector Residences, Occupants and Appliances

A total of twenty-six civilian dwellings were used in the analysis. These dwellings, constructed starting in 1975, occupied both single family and multifamily buildings. The dwelling construction was frame and stucco with wood or stone trim in some cases, generally similar to the construction of the military dwellings. Roofs were of cedar shake shingles. All dwellings, where applicable, had four inches of loose fiberglass fill thermal insulation on the ceilings. The furnace ducts were of 1/8 inch thick fiberous material, uninsulated. Windows were of aluminum frame, with most providing sliding panels for opening. A plan and elevation for a typical civilian dwelling are presented in Figures 6.3 and 6.4. The civilian dwellings were constructed with four dwelling units per lot.

Table 6.3. Detailed Military Occupant Data

DWELLING NO.	OCCUP	ADULTS	ADULT AGE BRACKET: 18-25	26-30	31-40	41-50	OVER 50	CHILDREN AGES			
2	5	2			2			13	11	6	
3	4	3	1		1	1		4			
4	4	2	1		2			17	8		
6	6	4	2		2			16	15		
7	5	3		1	1	1		7	3		
8	4	2			2			8	5		
9	5	2			2			14	11	7	
10	6	4	2		2			14	10		
11	2	1		1				3			
12	4	2			2			13	9		
13	3	1			1			17	16		
14	5	2			2			12	9	6	
16	3	2		1	1			11			
18	3	2			2			10			
20	5	2			2			15	14	13	
21	6	2			2			13	10	6	2
24	5	2			1	1		16	15	7	
25	6	2			1	1		13	10	8	5
28	3	2			2			1			
29	4	3	1		2			17			
TOTALS	88	45	7	3	32	4	0	43			
%	100	51	8	3	36	5	0	49			

THE AVERAGE AGE OF CHILDREN IS 10

Table 6.4. Appliances in Military Residences

DWELLING NO.	MICROWAVE	DISHWASHER	REFRIGERATOR	FREEZER GARAGE	FREEZER INDOORS	WASHER	GAS DRYER	ELEC DRYER	TELEVISION
2	0	0	2	0	0	1	0	1	2
3	0	0	2	0	0	1	0	1	1
4	0	0	2	1	0	1	0	1	3
6	0	1	1	0	1	1	0	1	2
7	0	0	1	1	0	1	0	1	1
8	1	0	2	0	0	1	0	1	1
9	1	0	1	1	0	1	0	1	2
10	1	1	2	1	0	1	0	1	1
11	0	0	1	0	0	1	1	0	1
12	0	0	1	0	0	1	0	1	1
13	0	0	1	1	0	1	0	1	0
14	1	1	2	0	0	1	0	1	2
16	0	0	1	0	0	1	0	1	1
18	1	1	1	1	0	1	0	1	1
20	0	0	2	0	0	1	0	1	1
21	0	1	1	0	1	1	0	1	1
24	1	0	1	0	0	1	0	1	1
25	0	0	1	0	0	1	1	0	3
28	0	0	2	1	0	1	0	1	2
29	1	1	1	0	1	1	1	0	1
AVERAGES PER DWELLING	0.35	0.3	1.4	0.35	0.15	1	0.15	0.85	1.4
				0.5			1		

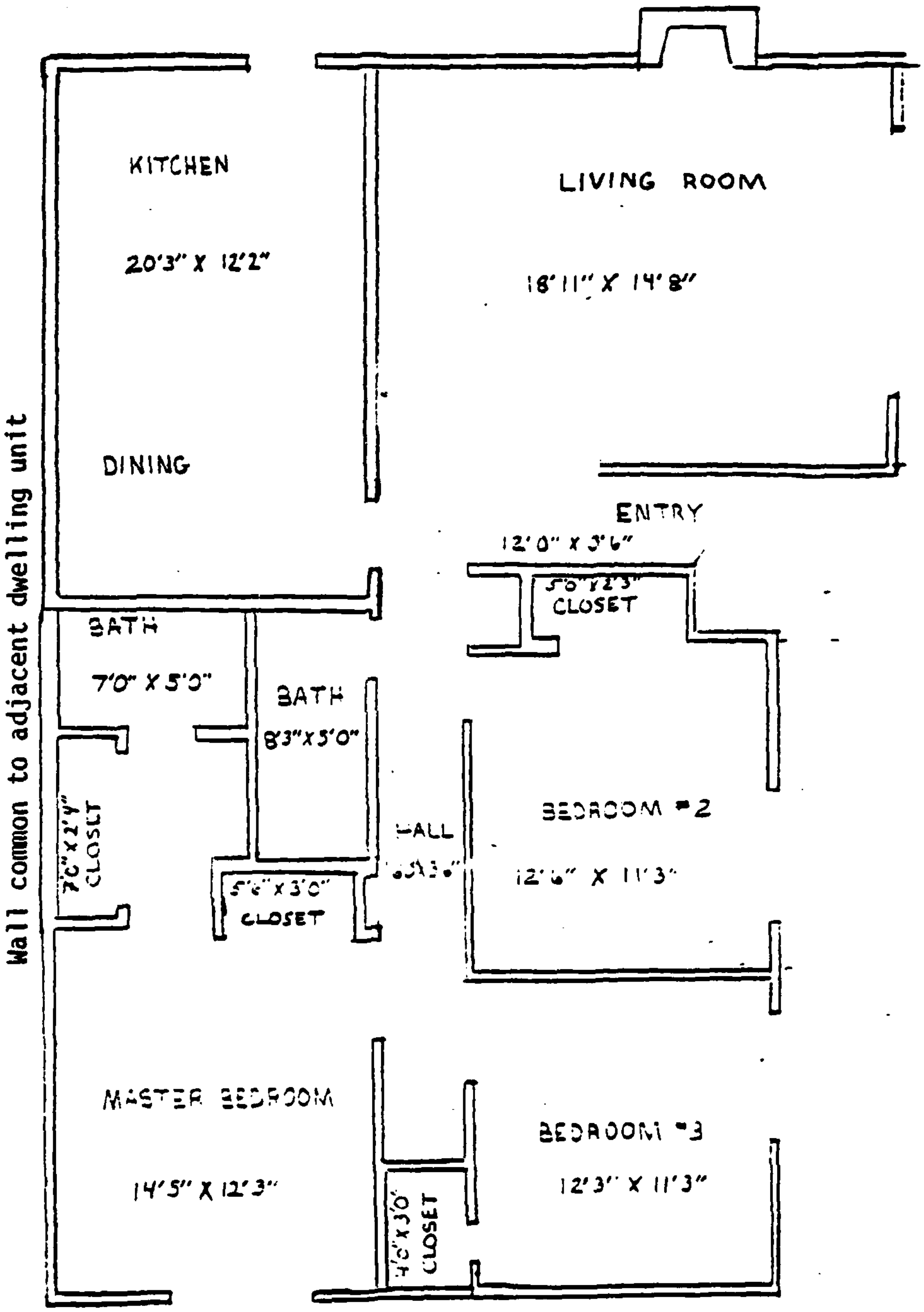

Figure 6.3. Plan of Typical Civilian Dwelling

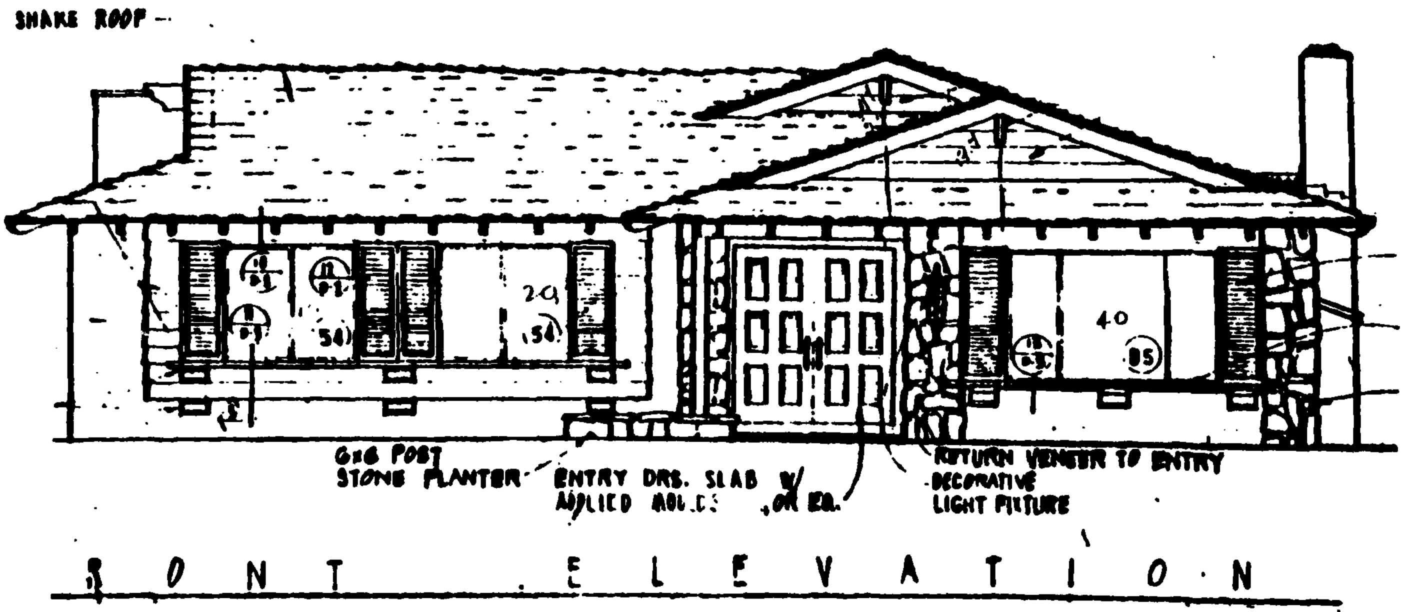

Figure 6.4. Elevation of Typical Civilian Dwelling

Table 6.5 presents dwelling and occupant data for the civilian residences as obtained in the on-site survey. Eighteen of the dwellings (including numbers 30 through 48) were of types quite similar to the military dwellings except that the Oxnard Marina units had thermal insulation in the walls, and the Main Street units had a common wall to an adjacent townhouse. Two dwellings (numbers 49 and 50) were townhouses with other dwelling units located above the ceiling and on one side. Six of the units (including numbers 52 through 58) had wooden floors over closed garages. Some of these garages contained clothes washers and dryers.

As seen in Table 6.5 for the civilian residences, number of occupants ranged between two and seven, and average number of occupants per dwelling was 3.88. The dwellings had two or three bedrooms, and the average number of occupants per bedroom was nearly the same as for military dwellings: 1.44. Floor areas ranged between 835 and 1321 square feet and the average per dwelling was 1065 square feet.

Structural and thermal data for the civilian residences was obtained from builder's plans and from a survey of each dwelling for input to the modified HEAP heating load analysis program. In addition, inspection of similar dwellings under construction at Oxnard Marina, and consultation with a foreman involved in the construction of the Oxnard Marina dwellings in this investigation, verified construction details.

All residences had forced air natural gas space heaters with a standby pilot light rated at 80,000 Btuh input and 64,000 Btuh output. Three bedroom dwellings had a 40 gallon natural gas water heater with standby pilot light rated at 46,000 Btuh input and 38.7 gallon per hour recovery at 100^{o}F temperature rise. Two

Table 6.5. Dwelling and Occupant Data for Civilian Residences

DWELLING NUMBER	LOCATION	NO. OCCUP.	NO. BEDROOMS	PLAN NO.	FLOOR AREA	WALL INSUL.	FLOOR	ATTIC
30	OX MARINA	5	3	5	1072	YES	S.O.C.	YES
31	OX MARINA	4	3	5	1072	YES	S.O.C.	YES
32	OX MARINA	2	3	5	1072	YES	S.O.C.	YES
33	OX MARINA	8	3	5	1072	YES	S.O.C.	YES
34	OX MARINA	4	3	5	1072	YES	S.O.C.	YES
35	OX MARINA	5	3	5	1072	YES	S.O.C.	YES
36	OX MARINA	7	3	5	1072	YES	S.O.C.	YES
37	OX MARINA	3	3	5	1072	YES	S.O.C.	YES
39	OX MARINA	3	3	5	1072	YES	S.O.C.	YES
40	OX MARINA	4	3	5	1072	YES	S.O.C.	YES
41	OX MARINA	3	3	5	1072	YES	S.O.C.	YES
42	OX MARINA	5	3	5	1072	YES	S.O.C.	YES
43	MAIN ST	4	3	6	1321	NO	S.O.C.	YES
44	MAIN ST	5	3	6	1321	NO	S.O.C.	YES
45	MAIN ST	4	3	6	1321	NO	S.O.C.	YES
46	MAIN ST	4	3	6	1321	NO	S.O.C.	YES
47	MAIN ST	5	3	6	1321	NO	S.O.C.	YES
48	MAIN ST	3	3	6	1321	NO	S.O.C.	YES
49	MAIN ST	2	2	7	951	NO	S.O.C.	NO
50	MAIN ST	3	2	7	951	NO	S.O.C.	NO
52	MAIN ST	2	2	8	835	NO	WOOD	YES
53	MAIN ST	4	2	8	835	NO	WOOD	YES
54	MAIN ST	3	2	8	835	NO	WOOD	YES
55	MAIN ST	2	2	8	835	NO	WOOD	YES
56	MAIN ST	3	2	8	835	NO	WOOD	YES
58	MAIN ST	4	2	8	835	NO	WOOD	YES
AVERAGES PER DWELLING		3.88	2.69		1065			

AVERAGE OCCUPANT PER BEDROOM: 1.44

bedroom dwellings had a 30 gallon natural gas water heater with a standby pilot light rated at 40,000 Btuh input and 33.6 gallon per hour recovery at 100°F temperature rise.

Detailed occupant data is presented in Table 6.6. Fifty-six percent of the occupants were adults and forty percent were in the 18 to 30 year age bracket. The average age of children was 6.

Data on appliances in the civilian residences is presented in Table 6.7. All dwellings were furnished with built-in dishwashers and had one refrigerator, no freezer, and no microwave oven. The average number of TV sets was one per dwelling and the average number of clothes washers and dryers was 0.65 per dwelling. All civilian clothes dryers used natural gas.

6.1.3 Comparison of Residences, Occupants and Appliances in Military and Civilian Dwellings

In order to evaluate the civilian and military sectors on some common basis, the basic survey data was normalized on an average per occupant or average per dwelling basis. Table 6.8 presents a comparison of average dwelling data. The average floor area and number of occupants per dwelling was larger for the military sector than the civilian sector, however, the average number of occupants per square foot of floor area and per bedroom is nearly the same for both civilian and military sectors.

Table 6.9 presents average occupancy data. There is a somewhat higher percent of adults in the civilian dwellings compared to the military dwellings, and the age brackets of the civilian occupants was generally lower than for the military occupants. The average age of civilian children was four years younger than for the military children.

Table 6.6. Detailed Civilian Occupant Data

DWELLING NO.	OCCUP	ADULTS	ADULT AGE BRACKET: 18-25	26-30	31-40	41-50	OVER 50	CHILDREN AGES				
30	5	2		2				14	13	11		
31	4	2		2				12	8			
32	2	2	1				1					
33	8	3	1	2				8	6	4	2	2
34	4	2		2				7	3			
35	5	4	4					1				
36	7	4	3		1			4	2	1		
37	3	3	3									
39	3	2		2				6				
40	4	2				2		15	14			
41	3	2		2				4				
42	5	2			1	1		13	11	9		
43	4	2	1	1				2	1			
44	5	2	1	1				4	2	1		
45	4	2		1	1			4	2			
46	4	2	1	1				3	1			
47	5	1			1			16	14	11	8	
48	3	2		1	1			3				
49	2	2					2					
50	3	1	1					4	1			
52	2	2			1	1						
53	4	2		2				6	5			
54	3	1			1			9	8			
55	2	2				2						
56	3	2	2					1				
58	4	3	1	2				1				
TOTALS	101	56	19	21	7	6	3	45				
%	100	55	19	21	7	6	3	45				

THE AVERAGE AGE OF CHILDREN IS 6

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Table 6.7. Appliances in Civilian Residences

DWELLING NO.	MICROWAVE	DISHWASHER	REFRIGERATOR	FREEZER GARAGE	FREEZER INDOORS	WASHER	GAS DRYER	ELEC DRYER	TELEVISION
30	0	1	1	0	0	1	1	0	1
31	0	1	1	0	0	0	0	0	1
32	0	1	1	0	0	1	1	0	1
33	0	1	1	0	0	1	1	0	1
34	0	1	1	0	0	1	1	0	1
35	0	1	1	0	0	1	1	0	1
36	0	1	1	0	0	1	1	0	2
37	0	1	1	0	0	0	0	0	1
39	0	1	1	0	0	1	1	0	1
40	0	1	1	0	0	1	1	0	1
41	0	1	1	0	0	1	1	0	1
42	0	1	1	0	0	1	1	0	1
43	0	1	1	0	0	0	0	0	1
44	0	1	1	0	0	1	1	0	1
45	0	1	1	0	0	1	1	0	1
46	0	1	1	0	0	0	0	0	1
47	0	1	1	0	0	1	0	0	1
48	0	1	1	0	0	0	0	0	1
49	0	1	1	1	0	1	1	0	1
50	0	1	1	0	0	0	0	0	1
52	0	1	1	0	0	1	1	0	1
53	0	1	1	0	0	0	0	0	1
54	0	1	1	0	0	1	1	0	1
55	0	1	1	0	0	0	0	0	1
56	0	1	1	0	0	1	1	0	1
58	0	1	1	0	0	0	1	0	0
AVERAGES PER DWELLING	0	1	1	0.04	0	0.65	0.65	0	1
				0.04			0.65		

Table 6.8. Comparison of Dwelling and Occupancy Data for Civilian and Military Dwellings

Category	OVERALL AVERAGES	
	Civilian	Military
Average Dwelling Floor Area Square Feet Per Dwelling	1065	1239
Average Number of Occupants Per Dwelling	3.9	4.4
Average Number of Occupants Per Square Foot	.036	.036
Average Number of Bedrooms Per Dwelling	2.7	3.2
Average Number of Occupants Per Bedroom	1.4	1.4

Table 6.9. Comparison of Detailed Occupancy Data for Civilian and Military Dwellings

Category	OVERALL AVERAGES	
	Civilian	Military
Percentages of		
Adults	55	51
Children	45	49
Percentages in Age Brackets		
18 to 25	19	8
23 to 30	21	3
31 to 40	7	36
41 to 50	6	5
Over 50	3	0
Average Age of Children, Years	6	10

The military dwellings generally contained more appliances than the civilian dwellings, as seen in Table 6.10. An exception was dishwashers, which were built-in for the civilian dwellings.

6.1.4 Actual Energy Consumption

Actual energy consumption for civilian dwellings was measured and billed monthly for natural gas and bi-monthly for electricity. For military dwellings, both electricity and natural gas consumption was measured monthly at the same time, and mock bills were sent to each dwelling.

Data on civilian dwelling electricity and natural gas consumption was obtained (with permission from dwelling occupants) from Southern California Edison Company and Southern California Gas Company. Data on actual military dwelling energy consumption was obtained as part of the Mock Billing program.

All data was combined into three bimonthly billing periods. The billing periods were Late Winter, Spring, and Early Summer, as listed in Table 6.11. The midpoints of corresponding billing periods were within 10 days of each other. Lengths of billing periods varied between 56 and 62 days.

Actual natural gas consumption for military and civilian residences, listed by dwelling number, are presented in Tables 6.12 and 6.13 for the three billing periods. Also presented are the combined overall consumption values for the three billing periods. The units of gas consumption for each dwelling are average therms per day. (1 Therm = 10^5 Btu.)

Table 6.10. Comparison of Appliance Data for Civilian and Military Dwellings

Appliance	Overall Averages Per Dwelling	
	Civilian	Military
Microwave Oven	0	.35
Dishwasher	1.0	.3
Refrigerator	1.0	1.4
Freezer	.04	.5
Washer	.65	1.0
Dryer - Total	.65	1.0
- Gas	.65	.15
- Electric	0	.85
Television	1.0	1.4

Table 6.11. Bimonthly Billing Periods for Analysis of Energy Data

Billing Period	CIVILIAN Gas	CIVILIAN Electric	MILITARY Gas & Elec.
<u>LATE WINTER</u> - Period 1			
Starting Date	1-22	1-11	1-17
Ending Date	3-22	3-13	3-14
Midpoint Day Numbered from January 1	51.5	41.5	45
Days in Period	59	61	56
<u>SPRING</u> - Period 2			
Starting Date	3-22	3-13	3-14
Ending Date	5-21	5-10	5-15
Midpoint Day Numbered from January 1	111	101	104
Days in Period	60	58	62
<u>EARLY SUMMER</u> - Period 3			
Starting Date	5-21	5-10	5-15
Ending Date	7-20	7-11	7-18
Midpoint Day Numbered from January 1	171	161	167
Days in Period	60	62	61

Table 6.12. Military Dwellings, Actual Natural Gas Consumption, Therms Per Day

DWELLING NO.	BILLING PERIODS: 1	2	3	OVERALL
2	2.584	1.185	1.114	1.59
3	3.394	2.247	1.299	2.267
4	5.284	3.24	1.721	3.335
6	5.477	3.24	1.839	3.436
7	4.879	2.909	1.755	3.109
8	5.072	3.815	2.565	3.762
9	4.59	3.292	1.299	2.991
10	3.606	2.352	1.215	2.338
11	3.741	2.23	0.945	2.243
12	3.529	3.583	2.413	3.157
13	3.491	2.474	1.097	2.302
14	3.876	2.456	1.485	2.552
16	3.298	2.369	1.249	2.261
18	3.934	2.456	1.806	2.632
20	4.281	2.404	1.502	2.664
21	4.706	3.362	1.519	3.127
24	4.204	2.944	2.109	3.038
25	2.796	1.846	1.434	1.994
28	4.262	2.961	1.181	2.736
29	2.854	1.341	1.299	1.792

Table 6.13. Civilian Dwellings, Actual Natural Gas Consumption, Therms Per Day

DWELLING NO.	BILLING PERIODS: 1	2	3	OVERALL
30	4.082	2.772	1.98	2.938
31	3.277	2.016	1.296	2.19
32	2.746	1.728	1.314	1.925
33	4.338	2.862	1.908	3.029
34	3.167	1.674	1.17	1.997
35	3.332	2.448	1.71	2.492
36	2.178	1.566	1.278	1.671
37	1.812	1.278	1.098	1.394
39	2.581	1.836	1.044	1.816
40	4.503	2.376	2.16	3.005
41	2.727	1.638	1.08	1.81
42	3.02	2.178	1.818	2.335
43	4.741	2.898	1.656	3.089
44	4.906	3.006	1.926	3.27
45	5.144	3.366	1.062	3.18
46	4.521	3.024	1.926	3.149
47	4.247	2.34	1.584	2.715
48	3.386	1.98	1.08	2.142
49	1.666	1.17	0.81	1.213
50	1.684	1.908	1.35	1.647
52	1.538	1.206	1.026	1.255
53	1.94	1.458	0.756	1.382
54	2.782	2.142	1.026	1.979
55	3.441	2.358	1.548	2.444
56	3.679	2.448	1.422	2.51
58	3.35	2.088	0.936	2.118

Actual electric consumption for military and civilian dwellings is presented in Tables 6.14 and 6.15. This data is presented similarly to the gas consumption data in units of average Kilowatt-hours per day.

6.1.5 Comparison of Actual Energy Consumption

Comparison of actual total energy consumption was made using the same energy units, therms per day. Electric energy values were converted to therms per day and were added to natural gas consumptions to obtain total dwelling energy consumptions of each residence for each billing period. The combined consumption for all billing periods were also calculated.

Tables 6.16 and 6.17 present military and civilian energy consumptions in therms per day for the Late Winter billing period, based on Tables 6.12 through 6.15. The tables present natural gas, electric and total consumption for each dwelling. Presented at the bottom of Tables 6.16 and 6.17 are the average consumption values for all of the military and civilian dwellings. The average consumptions per occupant are also given. These consumption per occupant values were obtained by dividing total consumption for all dwellings by the total number of occupants in these dwellings.

Tables 6.18 through 6.21 present data Spring and Early Summer periods in the same format as the Late Winter period. Overall consumption for all periods is summarized in Tables 6.22 and 6.23.

Calculated average energy consumption per occupant for civilian and military occupants is summarized for all three billing periods and overall for the entire six months in Table

Table 6.14. Military Dwellings, Actual Electric Consumption, Kilowatt Hours Per Day

DWELLING NO.	BILLING PERIODS: 1	2	3	OVERALL
2	27.25	19.968	20.078	22.247
3	19.196	21.21	18.422	19.61
4	27.661	24.726	23.531	25.209
6	30.714	27.258	23.859	27.126
7	34.25	28.952	27.25	29.984
8	25.036	21.097	18.281	21.319
9	25.536	22.581	21.797	23.214
10	39.732	27.694	22.5	29.571
11	14.304	12.597	12.797	13.192
12	16.839	18.274	20.266	18.533
13	35.607	23.887	21.5	26.654
14	25.482	23.758	23.219	24.099
16	17.125	16.871	17.641	17.22
18	36.464	30.806	32.316	33.148
20	25.5	21.435	19.125	21.874
21	26.679	25.081	26.094	25.929
24	50.214	40.71	31.234	40.302
25	17.679	13.984	11.438	14.225
28	16.232	17.048	15.641	16.302
29	18.357	15.968	16.125	16.758

Table 6.15. Civilian Dwellings, Actual Electric Consumption, Kilowatt Hours Per Day

DWELLING NO.	BILLING PERIODS: 1	2	3	OVERALL
30	10.295	10.517	11.984	10.945
31	14.607	13.293	11.145	13
32	10.705	11.017	10.177	10.624
33	12.164	12.586	12.71	12.486
34	5.705	5.121	4.435	5.083
35	19.557	16.638	16.758	17.663
36	13.721	14.466	13.29	13.812
37	13.803	17.259	7.887	12.884
39	9.607	8.948	9.097	9.221
40	19.475	17.31	18.661	18.503
41	12.705	11.224	10.274	11.398
42	17.639	15.086	16.323	16.37
43	13.557	12.552	10.774	12.282
44	26.607	21.966	18.016	22.177
45	19.443	17.793	16.532	17.917
46	18.803	16.845	12.468	16.006
47	23.689	20.897	17.694	20.74
48	10.41	10.672	9.694	10.249
49	12.492	11.207	10.5	11.398
50	6.328	12.207	10.935	9:79
52	5.295	4.448	6.516	5.442
53	7.492	6.293	6.452	6.751
54	10.787	10.414	9.565	10.249
55	7.738	7.172	6.839	7.249
56	6.574	6.276	6.29	6.381
58	7.951	8.655	8.871	8.492

Table 6.16. Military Dwellings, First Billing Period, Late Winter Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
2	2.584	0.930	3.514
3	3.394	0.655	4.049
4	5.284	0.944	6.228
6	5.477	1.048	6.525
7	4.879	1.169	6.048
8	5.072	0.854	5.926
9	4.590	0.872	5.462
10	3.606	1.356	4.962
11	3.741	0.488	4.229
12	3.529	0.575	4.104
13	3.491	1.215	4.706
14	3.876	0.870	4.746
16	3.298	0.584	3.882
18	3.934	1.245	5.179
20	4.281	0.870	5.151
21	4.706	0.911	5.617
24	4.204	1.714	5.918
25	2.796	0.603	3.399
28	4.262	0.554	4.816
29	2.854	0.627	3.481
AVG PER DWELLING	3.993	0.904	4.897
AVG PER OCCUPANT	0.907	0.206	1.113

AVERAGE OCCUPANT PER DWELLING IS 4.4

Table 6.17. Civilian Dwellings, First Billing Period, Late Winter, Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
30	4.082	0.351	4.433
31	3.277	0.499	3.776
32	2.746	0.365	3.111
33	4.338	0.415	4.753
34	3.167	0.195	3.362
35	3.332	0.667	3.999
36	2.178	0.468	2.646
37	1.812	0.471	2.283
39	2.581	0.328	2.909
40	4.503	0.665	5.168
41	2.727	0.434	3.161
42	3.020	0.602	3.622
43	4.741	0.463	5.204
44	4.906	0.908	5.814
45	5.144	0.664	5.808
46	4.521	0.642	5.163
47	4.247	0.809	5.056
48	3.386	0.355	3.741
49	1.666	0.426	2.092
50	1.684	0.216	1.900
52	1.538	0.181	1.719
53	1.940	0.256	2.196
54	2.782	0.368	3.150
55	3.441	0.264	3.705
56	3.679	0.224	3.903
58	3.350	0.271	3.621
AVG PER DWELLING	3.261	0.443	3.704
AVG PER OCCUPANT	0.839	0.114	0.953

AVERAGE OCCUPANT PER DWELLING IS 3.88

Table 6.18. Military Dwellings, Summary Second Billing Period, Spring, Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
2	1.185	0.683	1.867
3	2.247	0.734	2.971
4	3.240	0.844	4.084
6	3.240	0.930	4.170
7	2.909	0.988	3.897
8	3.815	0.720	4.535
9	3.292	0.771	4.063
10	2.352	0.945	3.297
11	2.230	0.430	2.660
12	3.588	0.624	4.212
13	2.474	0.815	3.289
14	2.456	0.811	3.267
16	2.369	0.576	2.945
18	2.456	1.051	3.507
20	2.404	0.732	3.136
21	3.362	0.856	4.218
24	2.944	1.389	4.333
25	1.846	0.477	2.323
28	2.961	0.582	3.543
29	1.341	0.545	1.886
AVG PER DWELLING	2.636	0.775	3.410
AVG PER OCCUPANT	0.599	0.176	0.775

AVERAGE OCCUPANT PER DWELLING IS 4.4

Table 6.19. Civilian Dwellings, Summary, Second Billing Period, Spring, Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
30	2.772	0.359	3.131
31	2.016	0.454	2.470
32	1.728	0.376	2.104
33	2.862	0.430	3.292
34	1.674	0.175	1.849
35	2.448	0.568	3.016
36	1.566	0.494	2.060
37	1.278	0.589	1.867
39	1.836	0.305	2.141
40	2.376	0.591	2.967
41	1.638	0.383	2.021
42	2.178	0.515	2.693
43	2.898	0.428	3.326
44	3.006	0.750	3.756
45	3.366	0.607	3.973
46	3.024	0.575	3.599
47	2.340	0.713	3.053
48	1.980	0.364	2.344
49	1.170	0.382	1.552
50	1.908	0.417	2.325
52	1.206	0.152	1.358
53	1.458	0.215	1.673
54	2.142	0.355	2.497
55	2.358	0.245	2.603
56	2.448	0.214	2.662
58	3.088	0.295	3.383
AVG PER DWELLING	2.145	0.421	2.566
AVG PER OCCUPANT	0.552	0.108	0.661

AVERAGE OCCUPANT PER DWELLING IS 3.88

Table 6.20. Military Dwellings, Summary, Third Billing Period, Early Summer, Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
2	1.114	0.685	1.799
3	1.299	0.629	1.928
4	1.721	0.803	2.524
6	1.839	0.814	2.653
7	1.755	0.930	2.685
8	2.565	0.624	3.189
9	1.299	0.744	2.043
10	1.215	0.768	1.983
11	0.945	0.437	1.382
12	2.413	0.692	3.105
13	1.097	0.734	1.831
14	1.485	0.792	2.277
16	1.249	0.602	1.851
18	1.806	1.110	2.916
20	1.502	0.653	2.155
21	1.519	0.891	2.410
24	2.109	1.066	3.175
25	1.434	0.390	1.824
28	1.181	0.534	1.715
29	1.299	0.550	1.849
AVG PER DWELLING	1.542	0.722	2.265
AVG PER OCCUPANT	0.351	0.164	0.515

AVERAGE OCCUPANT PER DWELLING IS 4.4

Table 6.21. Civilian Dwellings, Summary, Third Billing Period, Early Summer, Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
30	1.980	0.409	2.389
31	1.296	0.380	1.676
32	1.314	0.347	1.661
33	1.908	0.434	2.342
34	1.170	0.151	1.321
35	1.710	0.572	2.282
36	1.278	0.454	1.732
37	1.098	0.269	1.367
39	1.044	0.310	1.354
40	2.160	0.637	2.797
41	1.080	0.351	1.431
42	1.818	0.557	2.375
43	1.656	0.368	2.024
44	1.926	0.615	2.541
45	1.062	0.564	1.626
46	1.926	0.426	2.352
47	1.584	0.604	2.188
48	1.080	0.331	1.411
49	0.810	0.358	1.168
50	1.350	0.373	1.723
52	1.026	0.222	1.248
53	0.756	0.220	0.976
54	1.026	0.326	1.352
55	1.548	0.233	1.781
56	1.422	0.215	1.637
58	0.936	0.303	1.239
AVG PER DWELLING	1.383	0.386	1.769
AVG PER OCCUPANT	0.356	0.099	0.455

AVERAGE OCCUPANT PER DWELLING IS 3.88

Table 6.22. Military Dwellings, Summary Average for Six Months, Actual Energy Consumption, Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
2	1.590	0.759	2.349
3	2.267	0.669	2.936
4	3.335	0.860	4.195
6	3.436	0.926	4.362
7	3.109	1.023	4.132
8	3.762	0.728	4.490
9	2.991	0.792	3.783
10	2.338	1.009	3.347
11	2.243	0.450	2.693
12	3.157	0.633	3.790
13	2.302	0.910	3.212
14	2.552	0.822	3.374
16	2.261	0.588	2.849
18	2.682	1.131	3.813
20	2.664	0.747	3.411
21	3.127	0.885	4.012
24	3.038	1.376	4.414
25	1.994	0.485	2.479
28	2.736	0.556	3.292
29	1.792	0.572	2.364
AVG PER DWELLING	2.669	0.796	3.465
AVG PER OCCUPANT	0.607	0.181	0.787

AVERAGE OCCUPANT PER DWELLING IS 4.4

Table 6.23. Civilian Dwellings, Summary, Average for Six Months Actual Energy Consumption Therms Per Day

DWELLING NUMBER	ACTUAL CONSUMPTION GAS	ELEC	TOTAL
THERMS PER DAY			
30	2.938	0.374	3.312
31	2.190	0.444	2.634
32	1.925	0.363	2.288
33	3.029	0.426	3.455
34	1.997	0.173	2.170
35	2.492	0.603	3.095
36	1.671	0.471	2.142
37	1.394	0.440	1.834
39	1.816	0.315	2.131
40	3.005	0.632	3.637
41	1.810	0.389	2.199
42	2.335	0.559	2.894
43	3.089	0.419	3.508
44	3.270	0.757	4.027
45	3.180	0.612	3.792
46	3.149	0.546	3.695
47	2.715	0.708	3.423
48	2.142	0.350	2.492
49	1.213	0.389	1.602
50	1.647	0.334	1.981
52	1.255	0.186	1.441
53	1.382	0.230	1.612
54	1.979	0.350	2.329
55	2.444	0.247	2.691
56	2.510	0.218	2.728
58	2.118	0.290	2.408
AVG PER DWELLING	2.258	0.416	2.674
AVG PER OCCUPANT	0.581	0.107	0.688

AVERAGE OCCUPANT PER DWELLING IS 3.88

6.24. As seen for the Early Summer billing period where there are no heating loads, total energy consumption per occupant was 13% higher in the military sector compared with the civilian sector. However, military electric consumption was 66% greater than civilian consumption, and military gas consumption was 1% less than civilian consumption.

For the Late Winter billing period, total military energy consumption per occupant was 17% greater than civilian consumption per occupant. Electric consumption by the military occupants was 81% more than the electric consumption of the civilian occupants, and natural gas consumption was 8% more.

For all three billing periods covering six months, total energy of the military residences was 14% greater than for civilian residences. Electric consumption of military residences was 69% greater than that of civilian residences and natural gas consumption was 4% greater.

A factor influencing the larger electric consumption of the military residences compared to the civilian residences was the predominance of electric clothes dryers in the military dwellings compared to gas dryers in the civilian dwellings. The choice of electric dryers is influenced by the frequent moves required of military families. Natural gas connections may not be available for clothes dryers at some housing sites. Thus, a gas dryer is not considered a viable option by many military families.

In the dwellings surveyed, many military families owned food freezers while only one civilian family owned a freezer. As seen in Tables 6.3 and 6.6, the civilians surveyed were generally younger and had fewer and younger children than the military

Table 6.24. Energy Consumption Per Occupant at the Dwellings, All Seasons

CATEGORY		Actual Energy Consumption at Dwelling Including Building Heating Loads		
		Gas	Electric	Total
CIVILIAN DWELLINGS				
Late Winter	Therms	.839	.114	.953
Spring	Therms	.552	.108	.661
Early Summer	Therms	.356	.099	.455
Average for Six Months	Therms	.581	.107	.688
MILITARY DWELLINGS				
Late Winter	Therms	.907	.206	1.133
	% of Civilian	108	181	117
Spring	Therms	.599	.176	.775
	% of Civilian	109	163	117
Early Summer	Therms	.351	.164	.515
	% of Civilian	99	166	113
Average for Six Months	Therms	.607	.181	.787
	% of Civilian	104	169	114

families surveyed. It would be expected that families in the civilian sector of the same make-up and age as that of the military sector would have similar inventories of appliances.

Another factor in the military family electric consumption is the frequent use of a second refrigerator. Military supplied refrigerators are available with the Point Hueneme housing. However, many military families already had refrigerators and elected to keep both their own and the military supplied refrigerators.

As will be discussed later, the military dwellings surveyed required more heat than the civilian dwellings surveyed. Thus, electric consumption of the furnace blowers in the military dwellings was greater than in the civilian dwellings.

6.1.6 Norm Calculations

As a means of comparing energy consumptions of the civilian and military sectors, the energy consumptions of the appliances and dwellings were calculated using the norm procedures discussed in Section 3. Deviations of actual consumptions from the norm values of the military residences can be compared with those of the civilian residences to obtain adjusted energy consumption values for the occupants in the two groups.

The actual number of occupants and appliances in each dwelling was used for the calculations, except that it was assumed that there was only one refrigerator in each dwelling. (The extra electric consumption caused by second refrigerators, where used, was calculated also.) The Norm algorithm was not used for lighting loads. Instead, a constant 2.9 Kwh per day was assumed for each dwelling. Space heater-blower motor electric

consumption was included in the adjusted energy consumption values after heating requirements were determined.

6.1.6.1 Norm Electric Calculations

Tables 6.25 and 6.26 present the calculated electric appliance consumptiions for military and civilian residences, respectively. These tables present dwelling identification numbers, the number of dwelling occupants, and the electric consumptions of individual appliances in Kwh per day. Total appliance consumption is given also, including a second refrigerator where used. Although a single refrigerator consumption of 4.2 Kwh per day does not appear in the table, this value is represented in the totals.

The largest electric energy consumers in military residences were refrigerators, food freezers, electric clothes dryers, lights and the base load. The average overall daily electric consumptions per military dwelling was 15.1 Kwh, not including second refrigerators. The average overall daily electric consumption per military occupant was 3.44 Kwh. Food freezers, electric clothes dryers and the extra refrigerators accounted for 6.4 Kwh per dwelling, or 1.46 Kwh per occupant.

In the civilian residences, Table 6.26, the largest energy consumers were the refrigerator, lights and base load. Total calculated daily electric consumption was 11.4 Kwh per dwelling, or 2.95 Kwh per occupant.

A comparison of calculated average overall civilian and military electric consumption is presented in Table 6.27. This table presents values of total electric consumption per day,

Table 6.25.. Military Residences, Calculated Electric Consumption, Kilowatt Hours Per Day

DWELLING NO.	NO. OCCUP.	DISH WASHER	BASE LOAD	FREEZER	CLOTHES WASHER	GAS CLOTHES DRYER MOTOR	ELECTRIC CLOTHES DRYERS	TV	LIGHTS	TOTAL	TOTAL INCL. EXTRA FRIG.
2	5	0.000	1.708	0.000	0.334	0.000	3.577	1.418	2.900	14.130	18.338
3	4	0.000	1.490	0.000	0.267	0.000	2.974	0.945	2.900	12.776	16.976
4	4	0.000	1.490	3.960	0.267	0.000	2.974	2.835	2.900	18.626	22.826
6	6	0.574	1.927	3.960	0.402	0.000	4.180	1.418	2.900	19.560	19.560
7	5	0.000	1.708	3.960	0.334	0.000	3.577	0.945	2.900	17.625	17.625
8	4	0.000	1.490	0.000	0.267	0.000	2.974	0.945	2.900	12.776	16.976
9	5	0.000	1.708	3.960	0.334	0.000	3.577	1.418	2.900	18.098	18.098
10	6	0.574	1.927	3.960	0.402	0.000	4.180	0.945	2.900	19.087	23.287
11	2	0.000	1.053	0.000	0.133	0.177	0.000	0.945	2.900	9.408	9.408
12	4	0.000	1.490	0.000	0.267	0.000	2.974	0.945	2.900	12.776	12.776
13	3	0.000	1.272	3.960	0.200	0.000	2.371	0.000	2.900	11.903	14.903
14	5	0.485	1.708	0.000	0.334	0.000	3.577	1.418	2.900	14.623	18.823
16	3	0.000	1.272	0.000	0.200	0.000	2.371	0.945	2.900	11.888	11.888
18	3	0.307	1.272	3.960	0.200	0.000	2.371	0.945	2.900	16.155	16.155
20	5	0.000	1.708	0.000	0.334	0.000	3.577	0.945	2.900	13.665	17.865
21	6	0.574	1.927	3.960	0.402	0.000	4.180	0.945	2.900	19.087	19.087
24	5	0.000	1.708	0.000	0.334	0.000	3.577	0.945	2.900	13.665	13.665
25	6	0.000	1.927	0.000	0.402	0.418	0.000	2.835	2.900	12.681	12.681
28	3	0.000	1.272	3.960	0.200	0.000	2.371	1.418	2.900	16.321	20.521
29	4	0.396	1.490	3.960	0.267	0.297	0.000	0.945	2.900	14.456	14.456
AVG PER DWELLING		0.146	1.677	1.980	0.294	0.045	2.769	1.205	2.900	15.116	16.796
AVG PER OCCUPANT	4	0.033	0.359	0.450	0.067	0.010	0.629	0.274	0.659	3.435	3.817

Note: Calculated refrigerator load at all dwellings was 4.2 Kwh per day.

Table 6.26. Civilian Residences, Calculated Electric Consumption, Kilowatt Hours Per Day

DWELLING NO.	NO. OCCUP.	DISH WASHER	BASE LOAD	FREEZER	CLOTHES WASHER	GAS CLOTHES DRYER MOTOR	ELECTRIC CLOTHES DRYERS	TV	LIGHTS	TOTAL	TOTAL INCL. EXTRA FRIG.
30	5	0.485	1.708	0.000	0.334	0.358	0.000	0.945	2.900	10.931	10.931
31	4	0.396	1.490	0.000	0.000	0.000	0.000	0.945	2.900	9.931	9.931
32	2	0.218	1.053	0.000	0.133	0.177	0.000	0.945	2.900	9.626	9.626
33	8	0.752	2.364	0.000	0.536	0.539	0.000	0.945	2.900	12.235	12.235
34	4	0.396	1.490	0.000	0.267	0.297	0.000	0.945	2.900	11.726	11.726
35	5	0.485	1.708	0.000	0.334	0.358	0.000	0.945	2.900	12.161	12.161
36	7	0.663	2.143	0.000	0.469	0.478	0.000	1.418	2.900	13.503	13.503
37	3	0.307	1.272	0.000	0.000	0.000	0.000	0.945	2.900	10.884	10.884
39	3	0.307	1.272	0.000	0.200	0.237	0.000	0.945	2.900	11.291	11.291
40	4	0.396	1.490	0.000	0.267	0.297	0.000	0.945	2.900	11.726	11.726
41	3	0.307	1.272	0.000	0.200	0.237	0.000	0.945	2.900	11.291	11.291
42	5	0.485	1.708	0.000	0.334	0.358	0.000	0.945	2.900	12.161	12.161
43	4	0.396	1.490	0.000	0.000	0.000	0.000	0.945	2.900	11.161	11.161
44	5	0.485	1.708	0.000	0.334	0.358	0.000	0.945	2.900	12.161	12.161
45	4	0.396	1.490	0.000	0.267	0.297	0.000	0.945	2.900	11.726	11.726
46	4	0.396	1.490	0.000	0.000	0.000	0.000	0.945	2.900	11.161	11.161
47	5	0.485	1.708	0.000	0.334	0.000	0.000	0.945	2.900	11.803	11.803
48	3	0.307	1.272	0.000	0.000	0.000	0.000	0.945	2.900	10.884	10.884
49	2	0.218	1.053	3.960	0.133	0.177	0.000	0.945	2.900	14.816	14.816
50	3	0.307	1.272	0.000	0.000	0.000	0.000	0.945	2.900	10.854	10.854
52	2	0.218	1.053	0.000	0.133	0.177	0.000	0.945	2.900	10.856	10.856
53	4	0.396	1.490	0.000	0.000	0.000	0.000	0.945	2.900	11.161	11.161
54	3	0.307	1.272	0.000	0.200	0.237	0.000	0.945	2.900	11.291	11.291
55	2	0.218	1.053	0.000	0.000	0.000	0.000	0.945	2.900	10.546	10.546
56	3	0.307	1.272	0.000	0.200	0.237	0.000	0.945	2.900	11.291	11.291
58	4	0.396	1.490	0.000	0.000	0.297	0.000	0.000	2.900	10.514	10.514
AVG PER DWELLING		0.336	1.465	0.152	0.180	0.197	0.000	0.927	2.900	11.447	11.447
AVG PER OCCUPANT	3	0.099	0.377	0.039	0.046	0.051	0.000	0.239	0.747	2.947	2.947

Note: Calculated refrigerator load at all dwellings was 4.2 Kwh per day.

Table 6.27. Summary of Average Electric Consumption

Category	Calculated Electric Consumption Per Day	
	Per Dwelling	Per Occupant
Civilian Average Total Consumption		
Total Kwh/Day	11.4	2.95
W/O Clothes Dryer Kwh/Day	10.3	2.90
Military Average Total Consumption Including Extra Refrigerators		
Kwh/Day	16.8	3.82
% of Civilian Total	147	129
Without Extra Refrigerators		
Kwh/Day	15.1	3.44
% of Civilian Total	132	117
Without Extra Refrigerators, Freezers and Clothes Dryers		
Kwh/Day	10.4	2.36
% of Civilian Total	101	81

divided by either the number of dwellings or the number of occupants in the survey. The table shows that calculated average electric military consumption was 47% per dwelling, or 29% per occupant higher than civilian consumption. Discounting for the extra refrigerators, the calculated military consumption was 32% per dwelling, or 12% higher per occupant than the civilian consumption. When all are compared without freezers, clothes dryers and extra refrigerators, calculated military electric consumption per dwelling was only 1% higher than civilian consumption. However, military consumption per occupant was only 81% of civilian consumption.

6.1.6.2 Norm Natural Gas Consumption Due to Appliances

Calculated natural gas consumption, not including heating, is presented in Tables 6.28 and 6.29 for military and civilian residences, respectively. The tables show calculated gas consumption, in therms per day, for clothes dryers, water heaters and range/ovens, and the total for these three appliances. Also given in the table is the heat delivered inside the dwelling from all appliances. Averages per dwelling and averages per occupant are given also. A comparison of calculated natural gas consumption values are presented in Table 6.30. Calculated natural gas consumption per military dwelling was 2 to 6 percent higher than civilian consumption, according to whether the clothes dryers are considered in the comparison. Similarly, on an occupant basis, military natural gas consumption is 7 to 11 percent less than civilian consumption.

Table 6.28. Military Residences, Calculated Natural Gas Consumption from Appliances, and in Heat Delivered Inside Dwelling from all Appliances

DWELLING NO.	NO. OCCUP.	CLOTHES DRYER	WATER HEAT	RANGE OVEN	TOTAL	INTERNAL HEAT
2	5	0.000	1.177	0.197	1.374	0.283
3	4	0.000	1.049	0.188	1.237	0.273
4	4	0.000	1.049	0.133	1.237	0.273
6	6	0.000	1.306	0.205	1.311	0.447
7	3	0.000	1.177	0.197	1.374	0.283
8	4	0.000	1.049	0.138	1.237	0.273
9	5	0.000	1.177	0.197	1.374	0.283
10	6	0.000	1.306	0.205	1.511	0.312
11	2	0.060	0.791	0.172	1.024	0.254
12	4	0.000	1.049	0.188	1.237	0.273
13	3	0.000	0.920	0.180	1.100	0.263
14	5	0.000	1.177	0.197	1.374	0.299
16	3	0.000	0.920	0.180	1.100	0.263
18	3	0.000	0.920	0.180	1.100	0.274
20	5	0.000	1.177	0.197	1.374	0.283
21	6	0.000	1.306	0.205	1.511	0.447
24	5	0.000	1.177	0.197	1.374	0.283
25	6	0.143	1.306	0.205	1.654	0.295
28	3	0.000	0.920	0.180	1.100	0.263
29	4	0.102	1.049	0.188	1.339	0.423
AVG PER DWELLING	4	0.015	1.100	0.192	1.307	0.302
AVG PER OCCUPANT		0.003	0.250	0.044	0.297	0.069

Table 6.29. Civilian Residences, Calculated Natural Gas Consumption from Appliances, and in Heat Delivered Inside Dwelling from all Appliances

DWELLING	NO. OF OCCUP.	CLOTHES DRYER	WATER HEAT	RANGE OVEN	TOTAL	INTERNAL HEAT
30	5	0.122	1.177	0.197	1.496	0.301
31	4	0.000	1.049	0.188	1.237	0.277
32	2	0.060	0.791	0.172	1.024	0.262
33	8	0.184	1.564	0.221	1.969	0.341
34	4	0.102	1.049	0.188	1.339	0.330
35	5	0.122	1.177	0.197	1.496	0.343
36	7	0.163	1.435	0.213	1.811	0.369
37	3	0.000	0.920	0.180	1.100	0.309
39	3	0.031	0.920	0.180	1.131	0.317
40	4	0.102	1.049	0.188	1.339	0.330
41	3	0.081	0.920	0.180	1.181	0.317
42	5	0.122	1.177	0.197	1.496	0.343
43	4	0.000	1.049	0.188	1.237	0.319
44	5	0.122	1.177	0.197	1.496	0.343
45	4	0.102	1.049	0.188	1.339	0.330
46	4	0.000	1.049	0.188	1.237	0.319
47	5	0.000	1.177	0.197	1.374	0.341
48	3	0.000	0.920	0.180	1.100	0.309
49	2	0.060	0.791	0.172	1.024	0.304
50	3	0.000	0.920	0.180	1.100	0.309
52	2	0.060	0.791	0.172	1.024	0.304
53	4	0.000	1.049	0.188	1.237	0.319
54	3	0.031	0.920	0.180	1.131	0.316
55	2	0.000	0.791	0.172	0.963	0.298
56	3	0.081	0.920	0.180	1.181	0.316
58	4	0.102	1.049	0.188	1.339	0.319
AVG PER DWELLING	3	0.067	1.034	0.187	1.289	0.319
AVG PER OCCUPANT		0.017	0.256	0.048	0.302	0.082

Table 6.30. Summary of Average Natural Gas Consumption of Appliances

Category	Calculated Natural Gas Consumption of Appliances, Per Day	
	Per Dwelling	Per Occupant
Civilian Average		
With Clothes Dryer		
Therms/Day	1.29	.332
Without Clothes Dryer		
Therms/Day	1.22	.315
Military Average		
With Clothes Dryer		
Therms/Day	1.31	.297
% of Civilian	102	89
Without Clothes Dryer		
Therms/Day	1.29	.294
% of Civilian	106	93

6.1.6.3 Calculated Heating Loads

A heating season indoor temperature of 68°F was selected as the baseline indoor temperature of residences. Heating loads calculated using the modified HEAP program for both military and civilian residences with indoor temperatures of 68°F are presented in Tables 6.31 and 6.32. Heating requirements for each of the three billing periods was determined as well as the total consumption for the six month period. The results are presented as average therms per day. The calculations were made for each half of the two month billing periods, then combined. Weather data for the HEAP building load analysis was obtained from hourly records available from the nearby Point Mugu weather station. Calculated overall average heating loads for the two sectors are compared in Table 6.33. The military dwellings have considerably higher heat loads compared to the civilian dwellings. In the Late Winter billing period, the calculated utility dwelling heat load was 79% higher per dwelling and 58% higher per occupant than for the civilian dwellings.

6.1.7 Calculated Norm Energy Consumptions

Actual and Norm calculated energy consumptions are presented in Tables 6.34 through 6.39 for the military or civilian consumption for each billing period. Tables 6.40 and 6.41 present actual versus norm energy consumptions for the three billing periods representing the entire six months. The data is presented as average daily consumption values for natural gas (therms), electricity (Kwh) and the total energy consumption (therms) for each dwelling. Energy consumption values are given for actual Norms calculated, and the difference between actuals and norms (deviations from the norms). Averages per dwelling and per occupant are given at the bottom of the tables.

Table 6.31. Military Dwellings, Calculated Heat Load With Indoor Temperature of 68°F, Therms Per Day

DWELLING NO.	BILLING PERIODS: 1	2	3	OVERALL
2	2.42	0.931	0	1.062
3	2.217	0.845	0	0.97
4	2.117	0.699	0	0.899
6	2.539	0.944	0	1.103
7	2.121	0.727	0	0.901
8	2.073	0.62	0	0.849
9	2.072	0.604	0	0.843
10	1.85	0.607	0	0.776
11	2.127	0.788	0	0.923
12	2.189	0.779	0	0.939
13	2.061	0.689	0	0.869
14	2.004	0.632	0	0.832
16	2.05	0.68	0	0.862
18	2.308	0.756	0	-0.968
20	2.533	0.952	0	1.104
21	1.974	0.603	0	0.813
24	2.054	0.697	0	0.869
25	1.887	0.665	0	0.807
28	2.061	0.689	0	0.869
29	2.539	0.983	0	1.117
AVG PER DWELLING	2.160	.745		.918
AVG PER OCCUPANT	.491	.169		.209

Table 6.32. Civilian Dwellings, Calculated Heat Load With Indoor Temperature of 68°F, Therms Per Day

DWELLING NO.	BILLING PERIODS: 1	2	3	OVERALL
30	1.088	0.171	0	0.416
31	1.079	0.165	0	0.411
32	1.134	0.2	0	0.441
33	0.996	0.126	0	0.371
34	1.082	0.168	0	0.413
35	0.837	0.096	0	0.308
36	0.993	0.123	0	0.368
37	0.889	0.121	0	0.334
39	0.907	0.126	0	0.341
40	1.082	0.166	0	0.412
41	0.895	0.124	0	0.336
42	0.848	0.099	0	0.313
43	1.776	0.523	0	0.76
44	1.844	0.456	0	0.76
45	1.866	0.607	0	0.819
46	1.676	0.417	0	0.692
47	1.607	0.332	0	0.641
48	1.665	0.389	0	0.679
49	0.685	5.10000E-2	0	0.243
50	0.656	0.037	0	0.229
52	0.685	5.10000E-2	0	0.243
53	1.344	0.309	0	0.547
54	1.372	0.337	0	0.565
55	1.401	0.366	0	0.584
56	1.539	0.394	0	0.639
58	1.511	0.366	0	0.621
AVG PER DWELLING	1.210	.243		.480
AVG PER OCCUPANT	.311	.063		.124

Table 6.33. Calculated Heating Loads

Category		Calculated Building Heat Load Per Day	
		Per Dwelling	Per Occupant
CIVILIAN AVERAGE			
Late Winter		1.21	.311
Overall		.480	.124
MILITARY AVERAGE			
Late Winter	Therms	2.16	.491
	% of Civilian	179	158
Overall	Therms	.918	.209
	% of Civilian	191	169

Table 6.34. Energy Consumption, Actual, Calculated (NORM) and Differences, Late Winter, Military Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NORM	DIFF	ELECTRICITY Kwh PER DAY ACTUAL	NORM	DIFF	TOTAL THERMS PER DAY ACTUAL	NORM	DIFF
2	5	2.584	5.260	-2.676	27.250	15.304	11.946	3.514	5.782	-2.268
3	4	3.394	4.772	-1.378	19.196	13.837	5.359	4.049	5.244	-1.195
4	4	5.284	4.590	0.694	27.661	19.632	8.029	6.228	5.260	0.968
6	6	5.477	5.314	0.163	30.714	20.701	10.013	6.525	6.021	0.504
7	5	4.879	4.716	0.163	34.250	18.628	15.622	6.048	5.352	0.696
8	4	5.072	4.510	0.562	25.036	13.758	11.278	5.926	4.980	0.947
9	5	4.590	4.627	-0.037	25.536	19.074	6.462	5.462	5.278	0.183
10	6	3.606	4.307	-0.701	39.732	19.926	19.806	4.962	4.987	-0.025
11	2	3.741	4.428	-0.687	14.304	10.429	3.875	4.229	4.784	-0.555
12	4	3.529	4.721	-1.192	16.839	13.821	3.018	4.104	5.193	-1.089
13	3	3.491	4.369	-0.878	35.607	15.883	19.724	4.706	4.911	-0.205
14	5	3.876	4.474	-0.598	25.482	15.553	9.929	4.746	5.004	-0.259
16	3	3.298	4.349	-1.051	17.125	12.862	4.263	3.882	4.788	-0.906
18	3	3.934	4.799	-0.865	36.464	17.264	19.200	5.179	5.388	-0.210
20	5	4.281	5.466	-1.185	25.500	14.892	10.608	5.151	5.974	-0.823
21	6	4.706	4.287	0.419	26.679	19.920	6.759	5.617	4.967	0.650
24	5	4.204	4.595	-0.391	50.214	14.631	35.583	5.918	5.094	0.824
25	6	2.796	4.549	-1.753	17.679	13.550	4.129	3.399	5.011	-1.612
28	3	4.262	4.369	-0.107	16.232	17.301	-1.069	4.816	4.960	-0.144
29	4	2.854	5.186	-2.332	18.357	15.610	2.747	3.481	5.718	-2.238
AVG PER DWELLING		3.993	4.684	-0.692	26.493	16.129	10.364	4.897	5.235	-0.338
AVG PER OCCUPANT		0.907	1.065	-0.157	6.021	3.666	2.355	1.113	1.190	-0.077

Table 6.35. Energy Consumption, Actual, Calculated (NORM) and Differences, Late Winter, Civilian Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NORM	DIFF	ELECTRICITY Kwh PER DAY ACTUAL	NORM	DIFF	TOTAL THERMS PER DAY ACTUAL	NORM	DIFF
30	5	4.082	2.927	1.155	10.295	11.360	-1.065	4.433	3.314	1.119
31	4	3.277	2.695	0.582	14.607	10.368	4.239	3.776	3.049	0.727
32	2	2.746	2.610	0.136	10.705	10.102	0.603	3.111	2.954	0.157
33	8	4.338	3.160	1.178	12.164	12.593	-0.429	4.753	3.590	1.163
34	4	3.167	2.706	0.461	5.705	12.136	-6.431	3.362	3.120	0.242
35	5	3.332	2.394	0.938	19.557	12.430	7.127	3.999	2.818	1.181
36	7	2.178	2.945	-0.767	13.721	13.843	-0.122	2.646	3.417	-0.771
37	3	1.812	2.155	-0.343	13.803	11.170	2.633	2.283	2.536	-0.253
39	3	2.581	2.254	0.327	9.607	11.613	-2.006	2.909	2.650	0.258
40	4	4.503	2.706	1.797	19.475	12.136	7.339	5.168	3.120	2.048
41	3	2.727	2.232	0.495	12.705	11.606	1.099	3.161	2.628	0.532
42	5	3.020	2.414	0.606	17.639	12.436	5.203	3.622	2.838	0.784
43	4	4.741	3.886	0.855	13.557	11.956	1.601	5.204	4.294	0.910
44	5	4.906	4.225	0.681	26.607	12.979	13.628	5.814	4.668	1.146
45	4	5.144	4.131	1.013	19.443	12.564	6.879	5.808	4.560	1.247
46	4	4.521	3.704	0.817	18.803	11.901	6.902	5.163	4.110	1.053
47	5	4.247	3.675	0.572	23.689	12.493	11.196	5.056	4.102	0.954
48	3	3.386	3.566	-0.180	10.410	11.593	-1.183	3.741	3.962	-0.220
49	2	1.666	1.717	-0.051	12.492	15.024	-2.532	2.092	2.230	-0.137
50	3	1.684	1.732	-0.048	6.328	11.043	-4.715	1.900	2.108	-0.208
52	2	1.538	1.717	-0.179	5.295	11.064	-5.769	1.719	2.094	-0.376
53	4	1.940	3.100	-1.160	7.492	11.720	-4.228	2.196	3.500	-1.305
54	3	2.782	3.102	-0.320	10.787	11.867	-1.080	3.150	3.507	-0.357
55	2	3.441	2.968	0.473	7.738	11.148	-3.410	3.705	3.349	0.356
56	3	3.679	3.406	0.273	6.574	11.958	-5.384	3.903	3.814	0.090
58	4	3.350	3.505	-0.155	7.951	11.164	-3.213	3.621	3.886	-0.265
AVG PER DWELLING		3.261	2.909	0.352	12.967	11.933	1.034	3.704	3.316	0.387
AVG PER OCCUPANT		0.839	0.749	0.091	3.338	3.072	0.266	0.953	0.854	0.100

Table 6.36. Energy Consumption, Actual, Calculated (NORM) and Differences, Spring, Military Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NORM	DIFF	ELECTRICITY Kwh PER DAY ACTUAL	NORM	DIFF	TOTAL THERMS PER DAY ACTUAL	NORM	DIFF
2	5	1.185	2.553	-1.368	19.968	14.491	5.477	1.867	3.047	-1.181
3	4	2.247	2.277	-0.030	21.210	13.088	8.122	2.971	2.724	0.247
4	4	3.240	2.012	1.228	24.726	18.859	5.867	4.084	2.655	1.428
6	6	3.240	2.414	0.826	27.258	19.831	7.427	4.170	3.091	1.079
7	5	2.909	2.182	0.727	28.952	17.867	11.085	3.897	2.792	1.105
8	4	3.815	1.868	1.947	21.097	12.966	8.131	4.535	2.311	2.224
9	5	3.292	1.958	1.334	22.581	18.273	4.308	4.063	2.582	1.481
10	6	2.352	2.047	0.305	27.694	19.248	8.446	3.297	2.704	0.593
11	2	2.230	1.994	0.236	12.597	9.699	2.898	2.660	2.325	0.335
12	4	3.588	2.157	1.431	18.274	13.052	5.222	4.212	2.603	1.609
13	3	2.474	1.875	0.599	23.887	15.135	8.752	3.289	2.391	0.898
14	5	2.456	1.979	0.477	23.758	14.804	8.954	3.267	2.484	0.782
16	3	2.369	1.858	0.511	16.871	12.115	4.756	2.945	2.272	0.673
18	3	2.456	1.977	0.479	30.806	16.418	14.388	3.507	2.538	0.970
20	5	2.404	2.591	-0.187	21.435	14.030	7.405	3.136	3.070	0.066
21	6	3.362	1.794	1.568	25.081	19.172	5.909	4.218	2.449	1.769
24	5	2.944	2.127	0.817	40.710	13.891	26.819	4.333	2.601	1.732
25	6	1.846	2.327	-0.481	13.984	12.883	1.101	2.323	2.767	-0.443
28	3	2.961	1.875	1.086	17.048	16.553	0.495	3.543	2.439	1.103
29	4	1.341	2.360	-1.019	15.968	14.762	1.206	1.886	2.864	-0.978
AVG PER DWELLING		2.636	2.111	0.524	22.695	15.357	7.338	3.410	2.635	0.775
AVG PER OCCUPANT		0.599	0.480	0.119	5.158	3.490	1.668	0.775	0.599	0.176

Table 6.37. Energy Consumption, Actual, Calculated (NORM) and Differences, Spring, Civilian Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NATURAL GAS THERMS PER DAY NORM	NATURAL GAS THERMS PER DAY DIFF	ELECTRICITY Kwh PER DAY ACTUAL	ELECTRICITY Kwh PER DAY NORM	ELECTRICITY Kwh PER DAY DIFF	TOTAL THERMS PER DAY ACTUAL	TOTAL THERMS PER DAY NORM	TOTAL THERMS PER DAY DIFF
30	5	2.772	1.496	1.276	10.517	10.931	-0.414	3.131	1.869	1.262
31	4	2.016	1.237	0.779	13.293	9.931	3.362	2.470	1.576	0.894
32	2	1.728	1.024	0.704	11.017	9.626	1.391	2.104	1.352	0.752
33	8	2.862	1.969	0.893	12.586	12.235	0.351	3.292	2.386	0.905
34	4	1.674	1.339	0.335	5.121	11.726	-6.606	1.849	1.739	0.110
35	5	2.448	1.496	0.952	16.638	12.161	4.477	3.016	1.911	1.105
36	7	1.566	1.811	-0.245	14.466	13.503	0.963	2.060	2.272	-0.212
37	3	1.278	1.100	0.178	17.259	10.854	6.405	1.867	1.471	0.396
39	3	1.836	1.181	0.655	8.948	11.291	-2.343	2.141	1.567	0.575
40	4	2.376	1.339	1.037	17.310	11.726	5.584	2.967	1.739	1.228
41	3	1.638	1.181	0.457	11.224	11.291	-0.067	2.021	1.567	0.454
42	5	2.178	1.496	0.682	15.086	12.161	2.925	2.693	1.911	0.782
43	4	2.898	1.608	1.290	12.552	11.272	1.280	3.326	1.992	1.334
44	5	3.006	1.701	1.305	21.966	12.222	9.744	3.756	2.118	1.637
45	4	3.366	1.842	1.524	17.793	11.877	5.916	3.973	2.248	1.726
46	4	3.024	1.415	1.609	16.845	11.214	5.631	3.599	1.798	1.801
47	5	2.340	1.374	0.966	20.897	11.803	9.094	3.053	1.777	1.276
48	3	1.980	1.246	0.734	10.672	10.897	-0.225	2.344	1.618	0.726
49	2	1.170	1.024	0.146	11.207	14.816	-3.609	1.552	1.529	0.023
50	3	1.908	1.100	0.808	12.207	10.854	1.353	2.325	1.471	0.854
52	2	1.206	1.024	0.182	4.448	10.856	-6.408	1.358	1.394	-0.037
53	4	1.458	1.237	0.221	6.293	11.161	-4.868	1.673	1.618	0.055
54	3	2.142	1.220	0.922	10.414	11.303	-0.889	2.497	1.606	0.892
55	2	2.358	1.086	1.272	7.172	10.583	-3.411	2.603	1.448	1.155
56	3	2.448	1.324	1.124	6.276	11.334	-5.058	2.662	1.711	0.952
58	4	2.088	1.424	0.664	8.655	10.539	-1.884	2.383	1.783	0.600
AVG PER DWELLING		2.145	1.357	0.787	12.341	11.468	0.873	2.566	1.749	0.817
AVG PER OCCUPANT		0.552	0.349	0.203	3.177	2.952	0.225	0.661	0.450	0.210

Table 6.38. Energy Consumption, Actual, Calculated (NORM) and Differences, Early Summer, Military Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NORM	DIFF	ELECTRICITY Kwh PER DAY ACTUAL	NORM	DIFF	TOTAL THERMS PER DAY ACTUAL	NORM	DIFF
2	5	1.114	1.374	-0.260	20.078	14.138	5.940	1.799	1.857	-0.057
3	4	1.299	1.237	0.062	18.422	12.776	5.646	1.928	1.673	0.254
4	4	1.721	1.237	0.484	23.531	18.626	4.905	2.524	1.873	0.651
6	6	1.839	1.511	0.328	23.859	19.560	4.299	2.653	2.179	0.475
7	5	1.755	1.374	0.381	27.250	17.625	9.625	2.685	1.976	0.709
8	4	2.565	1.237	1.328	18.281	12.776	5.505	3.189	1.673	1.516
9	5	1.299	1.374	-0.075	21.797	18.098	3.699	2.043	1.992	0.051
10	6	1.215	1.511	-0.296	22.500	19.087	3.413	1.983	2.162	-0.179
11	2	0.945	1.024	-0.079	12.797	9.408	3.389	1.382	1.345	0.037
12	4	2.413	1.237	1.176	20.266	12.776	7.490	3.105	1.673	1.431
13	3	1.097	1.100	-0.003	21.500	14.903	6.597	1.831	1.609	0.222
14	5	1.485	1.374	0.111	23.219	14.623	8.596	2.277	1.873	0.404
16	3	1.249	1.100	0.149	17.641	11.888	5.753	1.851	1.506	0.345
18	3	1.806	1.100	0.706	32.516	16.155	16.361	2.916	1.652	1.264
20	5	1.502	1.374	0.128	19.125	13.665	5.460	2.155	1.840	0.314
21	6	1.519	1.511	0.008	26.094	19.087	7.007	2.410	2.162	0.247
24	5	2.109	1.374	0.735	31.234	13.665	17.569	3.175	1.840	1.335
25	6	1.434	1.654	-0.220	11.438	12.681	-1.243	1.824	2.086	-0.262
28	3	1.181	1.100	0.081	15.641	16.321	-0.680	1.715	1.657	0.057
29	4	1.299	1.339	-0.040	16.125	14.456	1.669	1.849	1.832	0.017
AVG PER DWELLING		1.542	1.307	0.235	21.166	15.116	6.050	2.265	1.823	0.442
AVG PER OCCUPANT		0.351	0.297	0.053	4.810	3.435	1.375	0.515	0.414	0.100

Table 6.39. Energy Consumption, Actual, Calculated (NORM) and Differences, Early Summer, Civilian Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NORM	DIFF	ELECTRICITY Kwh PER DAY ACTUAL	NORM	DIFF	TOTAL THERMS PER DAY ACTUAL	NORM	DIFF
30	5	1.980	1.496	0.484	11.984	10.931	1.053	2.389	1.869	0.520
31	4	1.296	1.237	0.059	11.145	9.931	1.214	1.676	1.576	0.100
32	2	1.314	1.024	0.290	10.177	9.626	0.551	1.661	1.352	0.309
33	8	1.908	1.969	-0.061	12.710	12.235	0.475	2.342	2.386	-0.044
34	4	1.170	1.339	-0.169	4.435	11.726	-7.291	1.321	1.739	-0.418
35	5	1.710	1.496	0.214	16.758	12.161	4.597	2.282	1.911	0.371
36	7	1.278	1.811	-0.533	13.290	13.503	-0.213	1.732	2.272	-0.540
37	3	1.098	1.100	-0.002	7.887	10.854	-2.967	1.367	1.471	-0.104
39	3	1.044	1.181	-0.137	9.097	11.291	-2.194	1.354	1.567	-0.212
40	4	2.160	1.339	0.821	18.661	11.726	6.935	2.797	1.739	1.058
41	3	1.080	1.181	-0.101	10.274	11.291	-1.017	1.431	1.567	-0.136
42	5	1.818	1.496	0.322	16.323	12.161	4.162	2.375	1.911	0.464
43	4	1.656	1.237	0.419	10.774	11.161	-0.387	2.024	1.618	0.406
44	5	1.926	1.496	0.430	18.016	12.161	5.855	2.541	1.911	0.630
45	4	1.062	1.339	-0.277	16.532	11.726	4.806	1.626	1.739	-0.113
46	4	1.926	1.237	0.689	12.468	11.161	1.307	2.352	1.618	0.733
47	5	1.584	1.374	0.210	17.694	11.803	5.891	2.188	1.777	0.411
48	3	1.080	1.100	-0.020	9.694	10.854	-1.160	1.411	1.471	-0.060
49	2	0.810	1.024	-0.214	10.500	14.816	-4.316	1.168	1.529	-0.361
50	3	1.350	1.100	0.250	10.935	10.854	0.081	1.723	1.471	0.252
52	2	1.026	1.024	0.002	6.516	10.856	-4.340	1.248	1.394	-0.146
53	4	0.756	1.237	-0.481	6.452	11.161	-4.709	0.976	1.618	-0.642
54	3	1.026	1.181	-0.155	9.565	11.291	-1.726	1.352	1.567	-0.214
55	2	1.548	0.963	0.585	6.839	10.546	-3.707	1.781	1.323	0.458
56	3	1.422	1.181	0.241	6.290	11.291	-5.001	1.637	1.567	0.070
58	4	0.936	1.339	-0.403	8.871	10.514	-1.643	1.239	1.698	-0.459
AVG PER DWELLING		1.383	1.289	0.095	11.303	11.447	-0.144	1.769	1.679	0.090
AVG PER OCCUPANT		0.356	0.332	0.024	2.910	2.947	-0.037	0.455	0.432	0.023

Table 6.40. Energy Consumption, Actual, Calculated (NORM) and Differences, All Three Billing Periods, Military Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY			ELECTRICITY Kwh PER DAY			TOTAL THERMS PER DAY		
		ACTUAL	NORM	DIFF	ACTUAL	NORM	DIFF	ACTUAL	NORM	DIFF
2	5	1.590	2.791	-1.201	22.247	14.563	7.684	2.349	3.288	-0.939
3	4	2.267	2.505	-0.238	19.610	13.157	6.453	2.936	2.954	-0.017
4	4	3.335	2.357	0.978	25.209	18.962	6.247	4.195	3.004	1.191
6	6	3.436	2.703	0.733	27.126	19.918	7.208	4.362	3.383	0.979
7	5	3.109	2.498	0.611	29.984	17.962	12.022	4.132	3.111	1.021
8	4	3.762	2.285	1.477	21.319	13.091	8.228	4.490	2.731	1.758
9	5	2.991	2.393	0.598	23.214	18.403	4.811	3.783	3.021	0.762
10	6	2.338	2.355	-0.017	29.571	19.341	10.230	3.347	3.015	0.333
11	2	2.243	2.239	0.004	13.192	9.773	3.419	2.693	2.573	0.120
12	4	3.157	2.448	0.709	18.533	13.140	5.393	3.790	2.897	0.893
13	3	2.302	2.202	0.100	26.654	15.233	11.421	3.212	2.722	0.490
14	5	2.552	2.343	0.209	24.099	14.913	9.186	3.374	2.852	0.523
16	3	2.261	2.189	0.072	17.220	12.214	5.006	2.849	2.606	0.243
18	3	2.682	2.363	0.319	33.148	16.533	16.615	3.813	2.927	0.886
20	5	2.664	2.867	-0.203	21.874	14.113	7.761	3.411	3.349	0.062
21	6	3.127	2.176	0.951	25.929	19.287	6.642	4.012	2.834	1.178
24	5	3.038	2.440	0.598	40.302	13.985	26.317	4.414	2.917	1.496
25	6	1.994	2.585	-0.591	14.225	12.961	1.264	2.479	3.027	-0.548
28	3	2.736	2.202	0.534	16.302	16.651	-0.349	3.292	2.770	0.522
29	4	1.792	2.600	-0.808	16.758	14.834	1.924	2.364	3.106	-0.742
AVG PER DWELLING		2.669	2.427	0.242	23.326	15.452	7.874	3.465	2.954	0.511
AVG PER OCCUPANT		0.607	0.552	0.055	5.301	3.512	1.790	0.787	0.671	0.116

Table 6.41. Energy Consumption, Actual, Calculated (NORM) and Differences All Three Billing Periods, Civilian Residences

DWELLING NO.	NO. OCCUP.	NATURAL GAS THERMS PER DAY ACTUAL	NORM	DIFF	ELECTRICITY Kwh PER DAY ACTUAL	NORM	DIFF	TOTAL THERMS PER DAY ACTUAL	NORM	DIFF
30	5	2.938	1.705	1.233	10.945	10.993	-0.048	3.312	2.080	1.231
31	4	2.190	1.480	0.710	13.000	10.004	2.996	2.634	1.822	0.812
32	2	1.925	1.350	0.575	10.624	9.724	0.900	2.288	1.681	0.606
33	8	3.029	2.024	1.005	12.486	12.252	0.234	3.455	2.442	1.013
34	4	1.997	1.490	0.507	5.083	11.771	-6.688	2.170	1.891	0.279
35	5	2.492	1.496	0.996	17.663	12.161	5.502	3.095	1.911	1.184
36	7	1.671	1.811	-0.140	13.812	13.503	0.309	2.142	2.272	-0.130
37	3	1.394	1.146	0.248	12.884	10.867	2.017	1.834	1.517	0.317
39	3	1.816	1.225	0.591	9.221	11.304	-2.083	2.131	1.611	0.520
40	4	3.005	1.488	1.517	18.503	11.770	6.733	3.637	1.889	1.747
41	3	1.810	1.216	0.594	11.398	11.301	0.097	2.199	1.602	0.597
42	5	2.335	1.496	0.839	16.370	12.161	4.209	2.894	1.911	0.982
43	4	3.089	2.038	1.051	12.282	11.401	0.881	3.508	2.428	1.081
44	5	3.270	2.254	1.016	22.177	12.388	9.789	4.027	2.677	1.350
45	4	3.180	2.228	0.952	17.917	11.992	5.925	3.792	2.637	1.155
46	4	3.149	1.915	1.234	16.006	11.364	4.642	3.695	2.303	1.393
47	5	2.715	1.919	0.796	20.740	11.966	8.774	3.423	2.328	1.095
48	3	2.142	1.773	0.369	10.249	11.056	-0.807	2.492	2.151	0.341
49	2	1.213	1.024	0.189	11.398	14.816	-3.418	1.602	1.529	0.073
50	3	1.647	1.100	0.547	9.790	10.854	-1.064	1.981	1.471	0.510
52	2	1.255	1.024	0.231	5.442	10.856	-5.414	1.441	1.394	0.046
53	4	1.382	1.651	-0.269	6.751	11.285	-4.534	1.612	2.036	-0.424
54	3	1.979	1.635	0.344	10.249	11.427	-1.178	2.329	2.025	0.304
55	2	2.444	1.483	0.961	7.249	10.702	-3.453	2.691	1.848	0.843
56	3	2.510	1.769	0.741	6.381	11.467	-5.086	2.728	2.161	0.567
58	4	2.118	1.887	0.231	8.492	10.678	-2.186	2.408	2.252	0.156
AVG PER DWELLING	3	2.258	1.601	0.656	12.197	11.541	0.656	1.995	0.679	
AVG PER OCCUPANT		0.581	0.412	0.169	3.140	2.971	0.169	0.514	0.175	

Deviations from the norms are a measure of occupant energy usage patterns. For electricity, these deviations include second refrigerators where used. In the military residences, consistently high positive deviations from the electric norms were observed for dwellings No. 7, 18 and 24 for all billing periods. Civilian residences No. 44 and 47 had consistently high positive deviations from the electric Norm also. These high positive deviations indicate consistently high electric consumptions in some residences.

Consistent negative or low deviations from the electric norm were also observed, for example, in military dwellings No. 25, 28 and 29 and in civilian residences 34, 52 and 56. These negative or low deviations indicate consistently low energy consumption in some residences.

Consistent high or low consumption patterns in some residences can be observed for natural gas and total energy similar to that observed for electricity.

As a means of summarizing the data of Tables 6.34 through 6.41, actual consumptions per occupant, and consumptions as percentages of calculated norms are presented in Table 6.42a and 6.42b. Values are given for natural gas, electricity and total consumption for all billing periods, both for military and civilian residences. Table 6.42a shows that, except for natural gas in the early summer, all military energy consumption per occupant was higher than civilian consumption per occupant.

The percent of Norm values in Table 6.42b indicate that actual military electric consumption per occupant was significantly greater than the Norms compared to the civilian electric consumption. However, military consumption of natural gas and

Table 6.42a. Summary of Average Actual Energy Consumptions Per Occupant

Billing Period	Natural Gas Therms Per Day		Electricity Kwh Per Day		Total Therms Per Day	
	Actual Military	Actual Civilian	Actual Military	Actual Civilian	Actual Military	Actual Civilian
Late Winter	.907	.839	6.02	3.34	1.113	.953
Spring	.599	.552	5.16	3.18	.775	.661
Early Summer	.351	.356	4.81	2.91	.515	.455
Total	.607	.581	5.30	3.14	.787	.688

Table 6.42b. Average Actual Energy Consumptions, Percent of NORM Values

Billing Period	Natural Gas		Electricity		Total	
	Military	Civilian	Military	Civilian	Military	Civilian
Late Winter	85	112	164	109	94	112
Spring	125	158	148	108	130	147
Early Summer	118	107	140	99	124	105
Total	110	141	151	106	117	134

total energy was generally smaller than the Norms compared to civilian and their norm.

6.1.8 Comparisons of Military and Civilian Energy Consumption Against Their Respective Norms

To compare civilian and military energy consumptions, it can be assumed that the percent deviations from the Norm of civilian residences in the survey would be the same as that for civilian residences with occupants, energy consuming appliances and dwellings comparable to those of the military residences. With this assumption, military actual energy consumptions as percentages of comparable civilian consumptions can be determined by ratioing the military and civilian percent of Norm values of Table 6.42b. The resulting energy consumption comparisons are presented in Table 6.43a.

Estimates of energy consumptions of civilian residences that are comparable to those in actual military residences were calculated using actual military consumption values and the percentages of Table 6.43a. The actual military energy consumption and resulting comparable civilian consumptions are presented in Table 6.43b.

For the three billing periods, the average electric consumption per occupant of the military residences was 1.62 Kwh per day larger than for the comparable civilian residences. The current cost of electricity at Point Hueneme is $.0499 per Kwh. Thus, for a 30 day month, the average electric cost for military housing over comparable civilian housing is $2.42 per occupant or $10.67 per dwelling.

Analysis of the natural gas consumption for the three billing periods, with a natural gas cost of $.285 per therm,

Table 6.43a. Military Occupant Energy Consumption, Percent of Comparable Civilian Consumption

	Military Consumption % of Civilian		
	Natural Gas	Electric	Total
Late Winter	76	151	84
Spring	79	137	88
Early Summer	110	142	118
Total	78	144	88

Table 6.43b. Energy Consumption Per Occupant of Military Residences and Comparable Civilian Residences

Billing Period	Natural Gas Therms Per Day		Electricity Kwh Per Day		Total Therms Per Day	
	Actual Military	Comparable Civilian	Actual Military	Comparable Civilian	Actual Military	Comparable Civilian
Late Winter	.907	1.193	6.02	3.99	1.113	1.325
Spring	.599	.758	5.16	3.77	.775	.881
Early Summer	.351	.319	4.81	3.39	.515	.436
Total	.607	.778	5.30	3.68	.787	.894

shows that for a 30 day month, the natural gas cost was $1.46 per occupant or $6.43 per dwelling less than for comparable civilian housing. Overall energy costs for a 30 day billing period were $.96 per occupant or $4.24 per residence more than for comparable civilian housing.

As indicated in Table 6.43a, military natural gas consumption during the non-heating Early Summer billing period was 10% greater than the consumption in the comparable civilian housing. The algorithms used for adjusting natural gas do not account for children ages, which may influence hot water heating and clothes dryer energy consumption, and which may lower the differences between consumptions of military and comparable civilian residences.

During the heating season, natural gas consumption in the military residences was 21% less than for the comparable civilian residences. Thus, the heating season consumption indicates that the military occupants conserved heating energy, and that thermostat settings and temperatures in military residences were generally lower than in the comparable civilian residences.

Military electric usage was 37% to 51% greater than comparable civilian usage. The magnitudes of these values suggest that the military residences were using excessive electricity. However, important differences between military and civilian appliance inventories and energy usage requirements may influence the values of the energy differences.

For example, military dress requirements may dictate more laundry loads than predicted in the algorithms, and the heavier fabrics of military uniforms may require more dryer

energy, and require more ironing than civilian clothing. In addition, the older children in the military residences compared to the civilian children, may require more laundry loads. A military residence requiring four additional loads per week would have daily electric consumption increased by 1.6 Kwh.

Military residences had outdoor lighting which could be left on all night for security reasons. Light bulbs supplied for this purpose had wattages totaling approximately 300 watts. A residence with lights on for three hours per night could consume an additional 0.9 Kwh per night.

Second refrigerators in the military dwellings consumed a calculated 4.2 Kwh per day in each dwelling where they were operating. If second refrigerators are considered, the average daily calculated Norm load would increase by 0.4 Kwh.

Even when the above additional energy values are added to the overall calculated energy consumption, adjusted military consumption was 25% more than the civilian consumption for the combined billing periods. This example indicates that adjusted military residence electric consumption will most likely be greater than civilian residence consumption even when adjustments are made possible for energy usage factors unique to military residences.

6.1.9 Conclusions

It is concluded that the natural gas consumption per occupant in military residences was 78% of comparable civilian residence consumption over the six month period studied. Natural gas appliance consumption per occupant in military residences was somewhat higher than for comparable civilian residences, but consumption for heating was considerably lower.

Electric consumption per occupant was 44% greater in military residences than in comparable civilian residences for the six month period. Adjustments for energy consumption requirements unique to military families might reduce the differences between military and comparable civilian residences, but it is most likely that even in these circumstances electric consumption in military compared to civilian residences would be greater. Total energy consumption per occupant of military residences was 88% of the comparable civilian residence consumption for the six month period.

It was found that civilian occupants in the survey were generally younger and had fewer and younger children than the military occupants. In addition, the civilian residences in the survey generally had fewer energy-consuming appliances than the military residences. Most civilian residences generally had natural gas heated clothes dryers, while most military residences had electric clothes dryers. These factors were accounted for in comparing energy consumptions.

6.2 EVALUATION OF ENERGY CONSERVATION MODIFICATIONS

6.2.1 Objective

The overall objective of this task is to assess the reductions of energy consumption in housing resulting from energy conservation modifications. For this purpose three different military family housing units, each in a different climatic region, have been selected as the baseline housing units for this task. The housing units were assumed to be located at the following installations to allow assessment of improvements in varying climatic zones:

- o Great Lakes Naval Training Center
- o Fort Hood Army Base
- o Port Hueneme

The approximate heating and cooling degree days for these locations are shown in Table 6.44 and indicate the three different climatic regions (cold in Great Lakes, mild in Port Hueneme, hot in Fort Hood).

TABLE 6.44

CLIMATIC CONDITIONS OF SITES EVALUATED

Location	Approximate Heating Degree Days (based on 65°F)	Approximate Cooling Degree Days (based on 65°F)
Great Lakes Naval Training Center	6000	1000
Fort Hood Army Base	1900	2900
Port Hueneme	1500	900

6.2.2 Methodology

For this analysis, annual weather data for these units have been obtained from nearest weather stations for each unit.* The weather data is based on approximately 30 years of measure-

*Local Climatological Data, Annual Summaries for 1975, NOAA, Department of Commerce.

ments which represent long-term average climatic characteristics of the regions. These data are on monthly basis and they give normal daily maximum, daily minimum temperatures, mean wind speed and relative humidity.

In order to access the reductions of energy consumption in housing units, several changes on thermal characteristics of the units will be assumed to be made. The thermal characteristics of the units which will be analyzed in this study are:

- o Exterior doors and windows
- o Exterior walls
- o Ceiling
- o Floor
- o Infiltration.

Individual changes in thermal characteristics of the units in the direction of reducing energy consumption will be assessed along with the effect of overall changes of thermal characteristics. The improvements in thermal characteristics for each unit will be made relative to a baseline unit with nominal thermal characteristics for its respective location. These changes are summarized in Section 6.2.3.

The modified HEAP program discussed in Section 3.4 was used to calculate the energy consumption for each housing unit for a set of specified thermal characteristics. This analysis was made on the monthly basis and the result totaled and presented on an annual basis.

6.2.3 Analysis

A typical house at each location was selected. The building size ranges from 1170 to 1510 square feet. The unit in Great Lakes Naval Training Center is a two story, four bedroom, townhouse end unit. The other two units are single story, four bedrooms. The unit in Fort Hood does not have an attic. All the units have frame construction with no basement. The construction materials of each baseline unit which has been selected for improvements is shown in Table 6.45a, b and c for Great Lakes, Fort Hood and Port Hueneme. The improvements in building components evaluated for the same units are shown in Table 6.46a, b and c.

The following assumptions have been made in order to calculate the energy consumptions for each housing unit:

- Indoor daytime dry-bulb temperature for winter = $68^{\circ}F$
- Indoor nighttime dry-bulb temperature for winter = $68^{\circ}F$
- Indoor daytime dry-bulb temperature for summer = $78^{\circ}F$

Table 6.45a
Contruction Material of the Baseline House in
Great Lakes Naval Training Center
(Building Size = 1510 square feet)

	Building Characteristics	Material and Construction
1.	Windows	Storm, metal sash
2.	Exterior doors	1", solid wood, storm
3.	Exterior walls	Wood siding, 5/8"; 15 lb. felt building paper; R-11 blanket insulation; nominal 2" x 4" wood studs; gypsum wall board, .5".
4.	Pitched roof	Asphalt shingle roofing; 15 lb. felt insulation; plywood sheating; .5".
5.	Floor	Porous gravel, 4"; concrete slab, 4"; vinyl asbestos tile, 3/32.".
6.	Infiltration	1 air change/hour

Table 6.45b
Construction Material of the Baseline House
in Fort Hood Army Base
(Building Size = 1380 square feet)

Building Characteristics	Material and Construction
1. Windows	Single glass, metal sash
2. Exterior walls	Stucco, 1", 15 lb. felt building paper; air space 3.5 in; nominal 2" x 4" wood studs; plywood board, 1/4"; plaster, lightweight aggregate.
3. Pitched roof	Asphalt shingle roofing; 15 lb. felt building paper; wood sheating, 1".
4. Floor	Porous gravel, 4"; concrete slab, 4"; vinyl asbesto tile, 3/32".
5. Infiltration	1 air change/hour

Table 6.45c

Construction Materials of the Baseline House in Port Hueneme (Building Size = 1170 square feet)

Building Characteristics	Material and Construction
1. Windows	Single glass, metal sash
2. Exterior walls	Stucco, 1"; 15 lb. felt building paper; air space 3.5 in; nominal 2" x 4" wood stud; plywood board, .25 in; metal lath and lightweight aggregate plaster.
3. Pitched roof	Asphalt shingle roofing; 15 lb. building paper; wood sheating, 1 in.
4. Ceiling	Plaster; gypsum board, .5 in; R-9 blanket insulation.
5. Floor	Porous gravel 4"; concrete slab, 4"; vinyl asbestos tile, 1/8".
6. Infiltration	1 air change/hour

Table 6.46a

Construction Material of Improved Components Evaluated at Great Lakes Naval Training Center (Building Size = 1510 square feet)

Building Characteristics	Material and Construction
1. Windows	Triple, wood sash
2. Exterior doors	2", Solid wood, storm
3. Exterior walls	The same except replacing R-11 with R-19 blanket insulation.
4. Pitched roof	Asphalt shingle roofing, 15 lb. felt building paper; plywood sheating .5"; non-reflective air space, 3.5"; nominal 2" x 4" ceiling rafter; gypsum wall board, .5".
5. Floor	The same except for addition of 1" edge insulation.
6. Infiltraton	.5 air change/hour

Table 6.46b

Construction Materials of Improved Components
Evaluated at Fort Hood Army Base
(Building Size = 1380 square feet)

Building Characteristics	Material and Construction
1. Windows	Double glass, metal sash
2. Exterior walls	The same except for addition of R-11 blanket insulation.
3. Pitched roof	Asphalt shingle roofing; 15 lb. felt building paper; wood sheating, 1"; non-reflective air space, 3.5"; nominal 2" x 4" ceiling rafter; gypsum wall board .5".
4. Floor	The same except 1" additon of edge insulation.
5. Infiltration	0.5 air change/hour

Table 6.46c

Construction Material of Improved Components
Evaluated at Port Hueneme
(Building Size = 1170 square feet)

Building Characteristics	Material and Constructon
1. Windows	Double glass, metal sash
2. Exterior walls	The same except for additions of R-11 blanket insulation.
3. Pitched roof	Asphalt shingle roofing; 15 lb. felt building paper; wood sheating, 1 in; non-reflective air space, 3.5; nominal 2" x 4" ceiling rafter; gypsum wall board, .5 in.
4. Ceiling	The same except replacing R-9 with R-19 blanket insulation.
5. Floor	The same except 1 in. addition of edge insulation.
6. Infiltration	0.5 air change/hour

- o Indoor nighttime dry-bulb temperature for summer = 78°F

- o Indoor daytime relative humidity for winter = 20%

- o Indoor nighttime relative humidity for winter = 20%

- o Indoor daytime relative humidity for summer = 50%

- o Indoor nighttime relative humidity for summer = 50%

- o Mean daytime wind speed = mean nighttime wind speed

- o Outdoor morning relative humidity is the average of outdoor relative humidity at 6 a.m. and 12 noon.

- o Outdoor afternoon relative humidity is the average of outdoor relative humidity at 12 noon and 6 p.m.

- o Daytime average outdoor dry-bulb temperature and nighttime average outdoor dry-bulb temperature have been calculated on the basis of maximum and minimum outdoor dry-bulb temperatures using cosine temperature profile method.

The modified HEAP program was run for each month for each unit for a specified thermal characteristics of the unit. The results are discussed in the following section.

6.2.4 Results

Table 6.47 through 6.49 represents the results of energy conservation due to improvements of thermal characteristics of the baseline housing units at Great Lakes, Fort Hood and Port Hueneme, respectively. The results indicate that improvements in attic roof or floor building materials generally will not result in significant reductions in energy consumption.

One point which should be noted here is that sometimes the effect of all improvements might not be equal to the sum of individual improvements. This is because it is not necessary to

Table 6.47. Annual Energy Conservation of the Baseline House in Great Lakes Naval Training Center Due to Building Thermal Characteristics Improvements

Table 6.47. Annual Energy Conservation of the Baseline House in Great Lakes Naval Training Center Due to Building Thermal Characteristics Improvements

Thermal Characteristics	Heating Requirements (10^6 Btu)	Heating Conservation (%)	Cooling Requirement (10^6 Btu)	Cooling Conservation (%)
None	49.49	--	15.81	--
Windows	43.74	12	16.48	-4.2
Exterior Doors	49.26	.5	15.82	0.0
Exterior Walls	45.32	8.4	15.70	.7
Roof	49.56	- .14	15.61	1.3
Floor	47.14	4.7	16.46	-4.1
Leakage Improvement	36.90	25.4	16.71	-5.7
All Improvements	26.16	47.1	18.12	-14.6

Table 6.48. Annual Energy Conservation of the Baseline House in Fort Hood Army Base Due to Building Thermal Characteristics Improvements

Thermal Characteristics	Heating Requirements (10^6 Btu)	Heating Conservation (%)	Cooling Requirements (10^6 Btu)	Cooling Conservation (%)
None	28.04	--	93.74	--
Windows	23.94	14.6	93.62	.1
Exterior Window	21.75	22.4	87.95	6.2
Roof	21.91	21.9	77.69	17.1
Floor	27.56	1.7	94.38	-.7
Leakage Improvement	25.41	9.4	90.84	3.1
All Improvements	9.19	67.2	69.54	25.8

Table 6.49. Annual Heating Energy Conservation of the Baseline House in Port Hueneme Due to Building Thermal Characteristics Improvements

Thermal Characteristics	Heating Requirements (10^6 Btu)	Heating Conservation (%)
None	16.27	--
Windows	9.62	41
Exterior Walls	7.56	53.50
Roof	16.40	-.8
Ceiling	14.64	10
Floor	15.42	5
Leakage Improvement	14.04	13.70
All Improvements	.50	96.90

implement all the improvements in order to have zero heating load in certain mild months of the year. The results pertaining to specific housing units are:

- <u>Great Lakes Naval Training Center housing unit:</u>

  This baseline housing unit which is located in a region of approximately 6000 heating degree days and only 1000 cooling degree days has a heating load of about 50×10^6 Btu and cooling load of about 16×10^6 Btu annually. The unit has 1510 square feet of floor space and is built with the exterior walls thermally insulated with R-11 blanket insulation and the house is equipped with storm windows. The following is noteworthy:

  1. More than half of the energy conservation for heating comes from improvements of leaks around the house.

  2. The next important improvement will be to replace the double glass windows with triple glass windows which reduces the heating energy consumption by about 12%.

  3. Replacing R-11 blanket insulation with R-19 blanket insulation in exterior walls decreases the heating load by 8%.

  4. More thermal insulation or reducing air leakage will result in increasing cooling load. As it is clear for Table 6.47, decreasing the air leakage from one change/hour to .5 change/hour will increase the cooling load by almost 6%. This is due to the fact that average outdoor dry-bulb temperatures in summer is lower than the inside dry-bulb temperature and reducing air leakage means less volume of cooler air infiltrates the building. This is also true with increasing the window or floor insulation where more thermal insulation causes less heat transmission from indoor to outdoor.

o <u>Fort Hood Army Base housing unit</u>

This baseline unit which is located in a region of approximately 1900 heating degree days and 2900 cooling degree days has a heating load of about 28 x 10^6 Btu and a cooling load of about 94 x 10^6 Btu annually. The results shown in Table 6.48 indicate:

1. About 22% of the heating load could be reduced by the addition of R-11 blanket insulation to exterior walls. This change will also decrease the cooling load by 6%.

2. About 22% of the heating load will be reduced by the addition of 3.5 in. air space to the roof. This change will also reduce the cooling load by 17%. (As it was mentioned earlier, this unit does not have an attic.)

3. A change in windows from single glass to double glass can reduce the heating load by almost 15% and leave almost no change in the cooling load.

4. The leakage improvements from 1 air change/hour to .5 air change/hour will reduce the heating load by almost 10% and cooling load by 3%.

o <u>Port Hueneme housing unit</u>

This baseline unit which is located in a region of approximately 1500 heating degree days has a heating load of about 16 x 10^6 Btu annually. The heating load seems to be low and this is because an indoor temperature of 68°F and 1 air change/hour for infiltration is assumed which practically the indoor temperature are kept above 68°F and the housing units could have more infiltration. The results shown in Table 6.49 indicate:

1. About half of the heating load could be reduced by the addition of R-11 blanket insulation to the exterior walls.

2. A change in windows from single glass to double glass can reduce the heating load by almost 40%.

3. The leakage improvements from 1 air change/hour to .5 air change/hour will reduce the heating load by almost 14%.

6.2.5 Conclusion

It should be noted that no cost benefit analysis has been performed on these analyses to evaluate the economic impacts of the thermal characteristics improvements made to the housing units.

Energy consumption analysis on three different housing units each located in a different climatic region will indicate the following important conclusions:

1. Replacing the single glass windows with double glass windows will result in significant reduction of heating loads.

2. Improvements in thermal characteristics of floors and attic roofs don't contribute a great deal to reduction of heating loads.

3. Improvements in air leakage will have a large effect on energy consumption and could be considered as a good portion of total energy saving.

4. Addition of R-11 or R-19 blanket insulation to exterior walls will significantly reduce the building loads but replacing R-11 with R-19 will not result in major reduction in heating loads.

7. CONCLUSIONS

The development of the norm calculational procedure as discussed in Section 3 and its evaluation in Section 4 indicate that there is good potential that the norm can with good accuracy serve as the norm algorithm for a billing procedure. There remains some additional technical issues to be evaluated concerning heating season performance (which is being addressed in a limited heating season field test) and the application to units where heating and cooling requirements are supplied by a central plant i.e. steam hot water or chilled water.

There also remains many administrative decisions to be made regarding the application of the norm. Administration concerns consist of the acquisition and classification of data which is not routinely entered in the system and policy on what is in the norm. The routine data are the measured energy consumptions and meteorological variables. Administrative data thus would include such items as:

- o Number of appliances allowed
- o Space conditioning temperatures
- o New family moving into a house
- o An increase or decrease in the number of occupants in the building
- o Building improvements and modifications
- o Readjustment of data found to be incorrect
- o Circumstances warranting special exceptions
- o Changes in norm criteria
- o New buildings
- o Length of billing period

This information is generally collected via telephone conversations, personal communications, written letters, notifications, etc. and has to be sorted and reduced in the form required by the system. This information would normally be entered immediately in the raw data base. The pre-processed data base, which results from running a computer program that has as input the raw data base, may be created at the end of the day or any other suitable time period. These parts of the billing process are shown in Figure 7.1 in the upper left hand side.

It is not conclusive from the evaluations of military versus civilian energy consumption at Port Hueneme that the military are overconsumers of energy. Their larger use of energy in this study appears to have justification in human factor considerations. In fact, on a total energy consumption basis, they were closer to the norm than the civilian residences.

Parameteric evaluations of energy conservation improvements to the buildings at the three sites investigated indicate large possible savings. However, without life cycle cost assessments no judgments can be made regarding the cost effectiveness of these improvements.

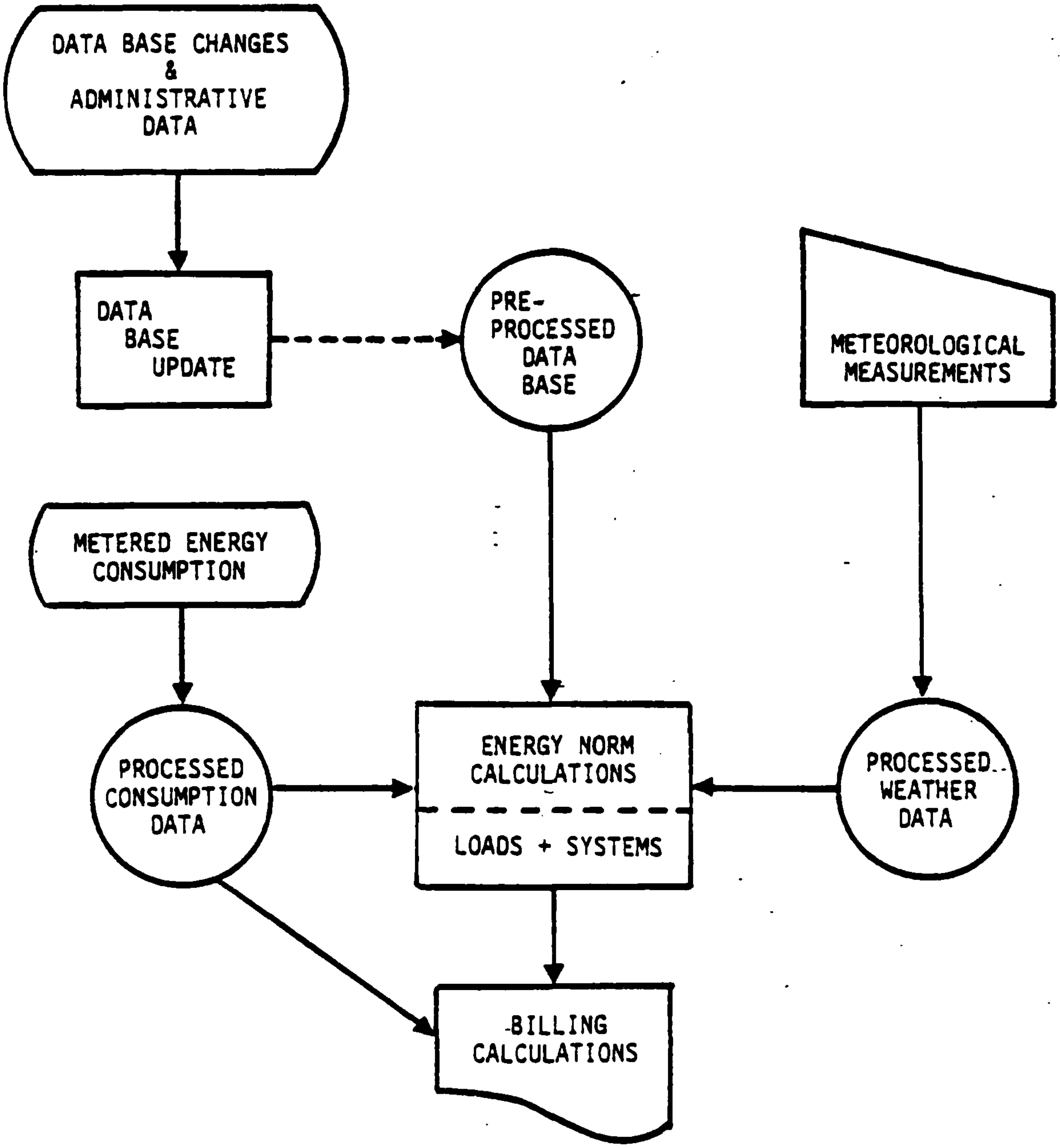

Figure 7.1. Functional Blocks of the Billing Procedure

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APPENDIX A

NORM APPLIANCE USAGE PROGRAM (NAUP)

COMPUTER LISTINGS

APPENDIX A

Norm Appliance Usage Program (NNAUP)
Computer Listings

Discussion

NAUP subroutines have been classified as being in one of the following groups:

Main Program:	Program NAUP.
Read Subroutines:	Read input data files and load the values of appliance operating/performance parameters in common storage.
Consumption Subroutines:	Calculate energy and hot water consumption for the billing period.
Print Subroutines:	Create output listings.
Miscellaneous Subroutines:	Perform miscellaneous functions such as initialization, zeroing between runs, summation of internal load components, and daily averaging of sunrise times, sunset times and time-of-year usage scale factors.

The groupings are presented in the order listed and the pages are numbered according to the group, e.g. AR-1 for the first page of read subroutines, AC-1 for consumption, AP-1 for print and AM-1 for miscellaneous.

The subroutines are alphabetically ordered within each group.

```
      PROGRAM  NAUP
C
C*****************************************************************************
C
C   "NAUP" IS THE  *** MAIN *** ROUTINE FOR THE ENERGY NORM
C  CALCULATIONS FOR THE NAVY.
C
C  R. J. RETTBERG   18 JULY 1978
C
C*****************************************************************************
C
      INCLUDE 'CAL.COM'
      COMMON /  CALI/ IDTOM(365)
C
      INCLUDE 'RUN.COM'
      COMMON/  RUNI/ NCASES, ICASE(100)
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
C
C--INITIALIZE.
C
      CALL ININS
C
C--READ THE RUN COMMAND DATA.
C
      CALL RUNR
C
C--LOOP OVER THE INDIVIDUAL CASES.
C
      DO 1200 I = 1, NCASES
C
C--INITIALIZE VARIABLES.
C
         CALL ZERO
C
C--DETERMINE THE RESIDENCE ID # & BILLING PERIOD DATES
C--   FOR THE FIRST SET OF CALCULATIONS.
C
         IX = ICASE(I)
         CALL CASER(IX)
C
         DO 1190 J = 1, NBPDS
            IBP   = J
            IDAY1 = IDAY1M(IBP)
            IDAY2 = IDAY2M(IBP)
            NBPDYS = IDAY2 - IDAY1 + 1
            IMNTH1 = IDTOM(IDAY1)
            IMNTH2 = IDTOM(IDAY2)
C
C---READ THE APPLIANCE DATA APPLICABLE TO THE RESIDENCE.
C
            IF(IBP .EQ. 1)CALL APRMS
C
C--READ THE WEATHER DATA FOR THE LOCATION.
C
            CALL WERMS
C
C--CALCULATE THE ENERGY CONSUMPTION.
C
            CALL APCMS
C
C--CALCULATE THE AVERAGE INTERNAL COOLING LOAD OVER THE BILLING
C--   PERIOD.
C
            CALL ILMS
C
C--PRINT OUT THE RESULTS FOR THIS CASE.
C
            CALL PRNTMS(IBP)
C
 1190    CONTINUE
 1200 CONTINUE
C
 9990 CONTINUE
      CALL EXIT
      END
```

APPENDIX A

READ SUBROUTINE LISTINGS

```
      SUBROUTINE APRMS
C
C**********************************************************************
C
C    MASTER SUBROUTINE FOR READING IN THE APPLIANCE DATA.
C
C     R. J. RETTBERG    18 JULY 1978
C
C**********************************************************************
C
C
C---READ THE DATA APPLICABLE TO THE RESIDENCE.
C
      CALL CDR
      CALL CWR
C     CALL DHR
      CALL DWR
C     CALL EBR
      CALL FRR
      CALL FUR
C     CALL HUR
      CALL IDR
      CALL LIR
C     CALL MEER
C     CALL MENGR
      CALL OCR
      CALL RER
      CALL ROR
      CALL TVR
C     CALL WBR
      CALL WHR
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CASER(IX)
C
C**************************************************************************
C
C  RUN INPUT READING SUBROUTINE.
C
C  R. J. RETTBERG   24 SEPT 1979.
C
C**************************************************************************
C
C  INPUT:
C      IX         = CASE # IN CASE.DAT.
C
C  OUTPUT:
C      NLOC       = LOCATION # OF THE RESIDENCE.
C      NRES       = RESIDENCE ID #.
C      IDAY1      = DATE OF 1-ST DAY OF BILLING PERIOD (E.G. 011479).
C      IDAY2      =  "     "  LAST  "   "    "      "
C      NBPDYS     = NUMBER OF BILLING PERIOD DAYS.
C      IMNTH      = MONTH NUMBER (1 - 12) FOR THE MIDDAY OF THE
C                   BILLING PERIOD.
C
C**************************************************************************
      INCLUDE 'CAL.COM'
      COMMON /  CALI/ IDTOM(365)
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
      OPEN (UNIT=50,DEVICE='DSK',ACCESS='SEQIN',FILE='CASE.DAT')
C
 1000 CONTINUE
      READ(50,*, END = 1050 ) IY
      READ(50,*) NRES, NBPDS
C
      DO 1020 I  = 1, NBPDS
         READ(50, *) IDAY1M(I), IDAY2M(I)
 1020 CONTINUE
C
      IF(IY .NE. IX)GO TO 1000
C
      NLOC = 1
      IF(NRES .LE. 1000) NLOC = 4
      IF(NRES .GT. 1200 .AND. NRES .LE. 1300) NLOC = 2
      IF(NRES .GT. 1300 .AND. NRES .LE. 1400) NLOC = 3
      IF(NRES .GT. 1400 .AND. NRES .LE. 1500) NLOC = 4
C
      GO TO 9990
C
 1050 CONTINUE
      WRITE(ITTY,6000) IX
 6000 FORMAT(' ***** EOF ON CASE.DAT W/O FINDING CASE', I3,
     &  ' *****')
C
 9990 CONTINUE
      CLOSE(UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE CDR
C
C*****************************************************************
C
C  CLOTHES DRYER INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*****************************************************************
C
C  REFERENCES:
C
C      1. SAI CW, CD, DW DE REPT:  P 5-39.
C
C*****************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &               IMNTH1, IMNTH2
      INCLUDE 'CD.COM'
      COMMON /  CDIE/ ICDE, ICDLE
      COMMON /  CDIG/ ICDNG, ICDLG, ICDPLT
      COMMON /  CDOG/ CDPPG
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--ASSUME STANDING PILOT LIGHTS ARE 1200 BTU / HOUR
C--   (REF 1.).  (REALLY 0.02 SCF / MIN IN REF.1).
C
      DATA CDPBPH/ 1200./
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='CD.DAT')
C
 1050 CONTINUE
      READ(50,*, END = 1900) IY, (DDUMA(JA), JA = 1,2)
      IF(DDUMA(1) .EQ. 'NG') READ(50, *) DDUMA(3)
      IF(IY .NE. NRES) GO TO 1050
C
      IF(DDUMA(1) .EQ. 'E') GO TO 1100
      ICDNG = 1
      ICDLG = 1
      IF(DDUMA(2) .EQ. 'U') ICDLG = 2
      ICDPLT = 1
      IF(DDUMA(3) .EQ. 'AID') ICDPLT = 2
      CDPPG = CDPBPH
      GO TO 9990
C
 1100 CONTINUE
      ICDE = 1
      ICDLE = 1
      IF(DDUMA(2) .EQ. 'U') ICDLE = 2
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE CWR
C
C**********************************************************************
C
C  CLOTHES WASHER INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C**********************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'CW.COM'
      COMMON /  CWIE/ ICWE, ICWLE
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='CW.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY, DDUMA(1)
      IF(IY .NE. NRES) GO TO 1050
      ICWE = 1
      ICWLE = 1
      IF(DDUMA(1) .EQ. 'U') ICWLE = 2
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE DWR
C
C************************************************************************
C
C  DISHWASHER INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG    20 SEPT 1979.
C
C************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'DW.COM'
      COMMON /  DWIE/ IDWE
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='DW.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY
      IF(IY .NE. NRES) GO TO 1050
      IDWE = 1
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE FRR
C
C*************************************************************************
C
C  FREEZER INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
      INCLUDE 'FR.COM'
      COMMON /  FRIE/ IFRE, IFRLE, FRPE
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='FR.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY
      READ(50, *) FRPE, DDUMA(1)
      IF(IY .NE. NRES) GO TO 1050
      IFRE = 1
      IFRLE = 1
      IF(DDUMA(1) .EQ. 'U') IFRLE = 2
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE FUR
C
C**********************************************************************
C
C  FURNACE INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C**********************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
      INCLUDE 'FU.COM'
      COMMON /  FUIE/ IFUE
      COMMON /  FUIG/ IFUNG, FUBPG, IFUPLT
      COMMON /  FUOG/ IFUPOO(2), FUPPG
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--ASSUME W/O JUSTIFICATION A 500 BTU / HOUR PILOT FOR AN
C--     80000 BTU / HOUR CAPACITY (INPUT) FURNACE THAT SCALES
C--     WITH CAPACITY.
C
      DATA FUPBPH/ 500./
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='FU.DAT')
C
 1050 CONTINUE
      READ(50,*, END = 1900) IY, DDUMA(1)
      IF(DDUMA(1) .EQ. 'NG') READ(50, *) FUBPG, DDUMA(2)
      IF(IY .NE. NRES) GO TO 1050
C
      IF(DDUMA(1) .EQ. 'E') GO TO 1100
      IFUNG = 1
      IFUPLT = 1
      IF(DDUMA(2) .EQ. 'AID') IFUPLT = 2
      FUPPG = FUPBPH * FUBPG / 80000.
C
C--ASSUME PILOT TURNED ON @ 11/1 (DAY 305) AND OFF @ 5/1 (DAY 121)..
C
      IFUPOO(1) = 305
      IFUPOO(2) = 121
      GO TO 9990
C
 1100 CONTINUE
      IFUE = 1
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE IDR
C
C**************************************************************************
C
C  RESIDENCE IDENTIFICATION INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C**************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'ID.COM'
      COMMON /   IDI/ IMVSC, FAMNAM(8), STREET(8), IDNTS(8)
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='ID.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY, DDUMA(1)
      READ(50, 6000) (FAMNAM(JA), JA = 1,8)
 6000    FORMAT(6X, 8A5)
      READ(50, 6000) (STREET(JA), JA = 1,8)
      READ(50, 6000) (IDNTS(JA), JA = 1,8)
      IF(IY .NE. NRES) GO TO 1050
      IMVSC = 1
      IF(DDUMA(1) .EQ. 'C') IMVSC = 2
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE LIR
C
C*******************************************************************************
C
C  LIGHTING (INCLUDING FLOOR PLAN) INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*******************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'LI.COM'
      COMMON / LIINR/ NBAR, NBER
      COMMON / LIISF/ ALTSF, AKSF, ALRSF, BASF(3), BESF(5),
     &                DENSF, DRSF, HWSF
      COMMON / LIIEI/ ALTPEI, AKPEI, ALRPEI, BAPEI(3), BEPEI(5),
     &                DENPEI, DRPEI, HWPEI, ODPEI
      COMMON / LIIEF/ ALTPEF, AKPEF, ALRPEF, BAPEF(3), BEPEF(5),
     &                DENPEF, DRPEF, HWPEF, ODPEF
      COMMON /LIIMIS/ ODHPD
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(73)
C
C--START EXECUTABLE STATEMENTS..
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='LI.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY, NBER, NBAR, NLNS
C
      DO 1060 I = 1, NLNS
         READ(50, *) DDUMA(I), DDUMB(I), DDUMC(I), DDUMD(I)
 1060 CONTINUE
C
      IF(IY .NE. NRES) GO TO 1050
C
      DO 1300 I = 1, NLNS
         DUMA = DDUMA(I)
         IF(DUMA .NE. 'K') GO TO 1110
         AKSF = DDUMB(I) + AKSF
         IF(DDUMD(I) .EQ. 'I') AKPEI = DDUMC(I)
         IF(DDUMD(I) .EQ. 'F') AKPEF = DDUMC(I)
         GO TO 1300
 1110    CONTINUE
         IF(DUMA .NE. 'LR') GO TO 1120
         ALRSF = DDUMB(I) + ALRSF
         IF(DDUMD(I) .EQ. 'I') ALRPEI = DDUMC(I)
         IF(DDUMD(I) .EQ. 'F') ALRPEF = DDUMC(I)
         GO TO 1300
 1120    CONTINUE
         IF(DUMA .NE. 'DEN') GO TO 1130
         DENSF = DDUMB(I) + DENSF
         IF(DDUMD(I) .EQ. 'I') DENPEI = DDUMC(I)
         IF(DDUMD(I) .EQ. 'F') DENPEF = DDUMC(I)
         GO TO 1300
 1130    CONTINUE
         IF(DUMA .NE. 'BE1') GO TO 1140
         BESF(1) = DDUMB(I) + BESF(1)
         IF(DDUMD(I) .EQ. 'I') BEPEI(1) = DDUMC(I)
         IF(DDUMD(I) .EQ. 'F') BEPEF(1) = DDUMC(I)
         GO TO 1300
 1140    CONTINUE
         IF(DUMA .NE. 'BE2') GO TO 1150
         BESF(2) = DDUMB(I) + BESF(2)
         IF(DDUMD(I) .EQ. 'I') BEPEI(2) = DDUMC(I)
         IF(DDUMD(I) .EQ. 'F') BEPEF(2) = DDUMC(I)
         GO TO 1300
 1150    CONTINUE
```

```
      IF(DUMA .NE. 'BE3') GO TO 1160
      BESF(3) = DDUMB(I) + BESF(3)
      IF(DDUMD(I) .EQ. 'I') BEPEI(3) = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') BEPEF(3) = DDUMC(I)
      GO TO 1300
1160  CONTINUE
      IF(DUMA .NE. 'BE4') GO TO 1170
      BESF(4) = DDUMB(I) + BESF(4)
      IF(DDUMD(I) .EQ. 'I') BEPEI(4) = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') BEPEF(4) = DDUMC(I)
      GO TO 1300
1170  CONTINUE
      IF(DUMA .NE. 'BE5') GO TO 1180
      BESF(5) = DDUMB(I) + BESF(5)
      IF(DDUMD(I) .EQ. 'I') BEPEI(5) = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') BEPEF(5) = DDUMC(I)
      GO TO 1300
1180  CONTINUE
      IF(DUMA .NE. 'BA1') GO TO 1190
      BASF(1) = DDUMB(I) + BASF(1)
      IF(DDUMD(I) .EQ. 'I') BAPEI(1) = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') BAPEF(1) = DDUMC(I)
      GO TO 1300
1190  CONTINUE
      IF(DUMA .NE. 'BA2') GO TO 1200
      BASF(2) = DDUMB(I) + BASF(2)
      IF(DDUMD(I) .EQ. 'I') BAPEI(2) = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') BAPEF(2) = DDUMC(I)
      GO TO 1300
1200  CONTINUE
      IF(DUMA .NE. 'BA3') GO TO 1210
      BASF(3) = DDUMB(I) + BASF(3)
      IF(DDUMD(I) .EQ. 'I') BAPEI(3) = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') BAPEF(3) = DDUMC(I)
      GO TO 1300
1210  CONTINUE
      IF(DUMA .NE. 'HW') GO TO 1220
      HWSF = DDUMB(I) + HWSF
      IF(DDUMD(I) .EQ. 'I') HWPEI = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') HWPEF = DDUMC(I)
      GO TO 1300
1220  CONTINUE
      IF(DUMA .NE. 'DR') GO TO 1230
      DRSF = DDUMB(I) + DRSF
      IF(DDUMD(I) .EQ. 'I') DRPEI = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') DRPEF = DDUMC(I)
      GO TO 1300
1230  CONTINUE
      IF(DUMA .NE. 'OD') GO TO 1240
      ODHPD = DDUMB(I)
      IF(DDUMD(I) .EQ. 'I') ODPEI = DDUMC(I)
      IF(DDUMD(I) .EQ. 'F') ODPEF = DDUMC(I)
      GO TO 1300
1240  CONTINUE
      WRITE(IWRITE, 6050) NRES, (DDUMA(JA), JA = 1,20)
6050     FORMAT(//, 3X, 'PROBLEM IN READING LIGHTING',
     &         ' DATA FOR RESIDENCE:', I7,
     &         //10X, 'ACRONYMS ARE AS FOLLOWS (1 OF',
     &         ' WHICH IS PROBABLY WRONG):',
     &         20(/, A5))
1300 CONTINUE
```

```
C
C--TOTAL THE WATTS & SQUARE FEET.
C
      ALTSF = 0.
      ALTPEI = 0.
      ALTPEF = 0.
C
      DO 1320 I = 1, NBAR
         ALTSF = ALTSF + BASF(I)
         ALTPEI = ALTPEI + BAPEI(I)
         ALTPEF = ALTPEF + BAPEF(I)
 1320 CONTINUE
C
      DO 1340 I = 1, NBER
         ALTSF = ALTSF + BESF(I)
         ALTPEI = ALTPEI + BEPEI(I)
         ALTPEF = ALTPEF + BEPEF(I)
 1340 CONTINUE
C
      ALTSF = ALTSF + AKSF + ALRSF + DENSF + DRSF + HWSF
      ALTPEI = ALTPEI + AKPEI + ALRPEI + DENPEI + DRPEI + HWPEI
     &       + ODPEI
      ALTPEF = ALTPEF + AKPEF + ALRPEF + DENPEF + DRPEF + HWPEF
     &       + ODPEF
C
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE OCR
C
C*****************************************************************************
C
C  OCCUPANT INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*****************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='OC.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY, NOCC
      IF(IY .NE. NRES) GO TO 1050
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE RER
C
C****************************************************************************
C
C  REFRIGERATOR INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C****************************************************************************
C
       INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &               IMNTH1, IMNTH2
       INCLUDE 'RE.COM'
      COMMON /  REIE/ NRE, IRELE(3), REPE(3)
C
       INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='RE.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY, NRE
C
      DO 1100 I = 1, NRE
         READ(50, *) REPE(I), DDUMA(I)
 1100 CONTINUE
C
      IF(IY .NE. NRES) GO TO 1050
C
      DO 1150 I = 1, NRE
         IRELE(I) = 1
         IF(DDUMA(I) .EQ. 'U') IRELE(I) = 2
 1150 CONTINUE
C
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE ROR
C
C**********************************************************************
C
C  RANGE & OVEN INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C**********************************************************************
C
C  REFERENCES:
C
C     1. SAI R & O DOE REPT:  P 6-10 (ASSUMING 2 SURFACE UNIT
C        PILOTS).
C
C**********************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                  IMNTH1, IMNTH2
      INCLUDE 'RO.COM'
      COMMON /  SUIE/ ISUE
      COMMON /  SUIG/ ISUNG, NSUPLS, ISUPLT
      COMMON /  OVIE/ IOVE
      COMMON /  OVIG/ IOVNG, NOVPLS, IOVPLT
      COMMON /  SUOG/ SUPPG
      COMMON /  OVOG/ OVPPG
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--ASSUME 150 BTU / HOUR / SURFACE-UNIT-PILOT &
C--    175 BTU / HOUR / OVEN-PILOT (REF. 1).
C
      DATA SUPBPH/ 150./
      DATA OVPBPH/ 175./
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=30, DEVICE='DSK',ACCESS='SEQIN',FILE='RO.DAT')
C
 1050 CONTINUE
      READ(30,*, END = 1900) IY, (DDUMA(JA), JA = 1,2)
      IF(DDUMA(1) .EQ. 'NGR') READ(30, *) (DDUMA(JA), JA = 3, 4)
      IF(DDUMA(2) .EQ. 'NGO') READ(30, *) (DDUMA(JA), JA = 5, 6)
      IF(IY .NE. NRES) GO TO 1050
C
      IF(DDUMA(1) .EQ. 'ER') GO TO 1100
      ISUNG = 1
      NSUPLS = DDUMA(3)
      ISUPLT = 1
      IF(DDUMA(4) .EQ. 'AID') ISUPLT = 2
      SUPPG = SUPBPH * FLOAT(NSUPLS)
      GO TO 1200
C
 1100 CONTINUE
      ISUE = 1
      GO TO 1200
C
 1200 CONTINUE
      IF(DDUMA(2) .EQ. 'EO') GO TO 1300
      IOVNG = 1
      NOVPLS = DDUMA(5)
      IOVPLT = 1
      IF(DDUMA(6) .EQ. 'AID') IOVPLT = 2
      OVPPG = OVPBPH * FLOAT(NOVPLS)
      GO TO 9990
C
 1300 CONTINUE
      IOVE = 1
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=30)
      RETURN
      END
```

```
      SUBROUTINE RUNR
C
C***********************************************************************
C
C  READS THE CASES IN CASE.DAT THAT WILL BE ANALYZED IN THE RUN.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C***********************************************************************
C
C  INPUT:
C     NCASES     = NUMBER OF CASES TO BE ANALYZED IN THE RUN.
C     ICASE(I)   = THE CASE NUMBERS IN "CASE.DAT"
C
C  OUTPUT:
C     FILLS COMMON/ - RUNI/ WITH THE INPUT DATA.
C
C***********************************************************************
C
      INCLUDE 'RUN.COM'
      COMMON/  RUNI/ NCASES, ICASE(100)
C
      OPEN(UNIT=50,DEVICE='DSK',ACCESS='SEQIN',FILE='RUN.DAT')
C
     -READ(50,*)NCASES, (ICASE(JA),JA=1,NCASES)
C
 9990 CONTINUE
      CLOSE(UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE RWR
C
C***********************************************************************
C
C  READ/WRITE UNIT & DEBUG FLAG ASSIGNMENT SUBROUTINE.
C
C  R. J. RETTBERG   15 OCT 1979
C
C***********************************************************************
C
C  NOTES:
C
C     1. DEBUG FLAGS ASSIGNED TO ALL SUBROUTINES AS LISTED IN DATA
C        STATEMENT ALTHOUGH THE SUBROUTINES MAY NOT BE CODED
C        TO UTILIZE THEM.
C
C     2. THERE MAY BE MORE FLAGS READ IN THAN THERE ARE SUBROUTINES.
C        THE EXTRAS JUST ARE NOT USED ANYWHERE.
C
C***********************************************************************
C
C
      PARAMETER INAME=51
C
      DOUBLE PRECISION NAME(INAME)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
      DATA NAME/ 'NNAUP   ',
     &          'INIMS   ',
     &          '   INIMSF',
     &          '   RWR   ',
     &          'RUNR     ',
     &          'ZERO     ',
     &          'CASER    ',
     &          'APRMS    ',
     &          '   CDR   ',
     &          '   CWR   ',
     &          '   DWR   ',
     &          '   FRR   ',
     &          '   IDR   ',
     &          '   LIR   ',
     &          '   OCR   ',
     &          '   RER   ',
     &          '   ROR   ',
     &          '   TVR   ',
     &          '   WHR   ',
     &          'WERMS    ',
     &          'APCMS    ',
     &          '   APMSFA',
     &          '   SRSSA ',
     &          '   BLCE  ',
     &          '   BLCN  ',
     &          '   BLCH  ',
     &          '   APCEMS',
     &          '      CDCE',
     &          '      CWCE',
     &          '      DWCE',
     &          '      FRCE',
     &          '      LICE',
     &          '      RECE',
     &          '      ROCE',
     &          '      TVCE',
     &          '   APCNMS',
     &          '      CDCN',
     &          '      ROCN',
     &          '   APCHMS',
     &          '      CWCH',
     &          '      DWCH',
     &          '   WHCE  ',
     &          '   WHCN  ',
     &          '   APCTOT',
     &          'ILMS     ',
```

```
     &              'PRNTMS    ',
     &              '    PRNTA ',
     &              '    PRNTB ',
     &              '    PRNTC ',
     &              '    PRNTD ',
     &              '    PRNTE '/
C
C---START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50,DEVICE='DSK',ACCESS='SEQIN',FILE='RW.DAT')
C
      READ(50,*) ITTY
      READ(50,*) IREAD
      READ(50,*) IWRITE
C
      DO 1050 I = 1, 15
         KA = 5*I - 4
         READ(50,*) (IPRNT(JA),JA=KA,KA+4)
 1050 CONTINUE
C
      IF(IPRNT(4).LT.1)GO TO 9990
C
      IWX = ITTY
 1100 CONTINUE
      WRITE(IWX,6100)
 6100 FORMAT(' HERE ARE THE ACTIVATED PRINT FLAGS OF IPRNT:')
      WRITE(IWX,6110)
 6110 FORMAT(//9X, 'I', 5X, 'SUBROUTINE', 5X, 'ACTIVE', /,
     &   8X, '--', 5X, '----------', 5X, '------', /)
C
      DO 1150 I=1, INAME
         IF(IPRNT(I).GT.0)GO TO 1140
         WRITE(IWX, 6120) I, NAME(I)
 6120    FORMAT(8X, I2, 5X, A10, 7X, '-')
         GO TO 1150
 1140    CONTINUE
         WRITE(IWX, 6130) I, NAME(I)
 6130    FORMAT(8X, I2, 5X, A10, 6X, 'YES')
 1150 CONTINUE
C
      IF(IWX .EQ. IWRITE)GO TO 9990
      IWX = IWRITE
      GO TO 1100
C
 9990 CONTINUE
      CLOSE(UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE TVR
C
C**************************************************************************
C
C  TELEVISION INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C**************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'TV.COM'
      COMMON /  TVIE/ NTV, ICVSM(3), TVPE(3)
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='TV.DAT')
C
 1050 CONTINUE
      READ(50, *, END = 1900) IY, NTV
C
      DO 1100 I = 1, NTV
         READ(50, *) TVPE(I), DDUMA(I)
 1100 CONTINUE
C
      IF(IY .NE. NRES) GO TO 1050
C
      DO 1150 I = 1, NTV
         ICVSM(I) = 1
         IF(DDUMA(I) .EQ. 'M') ICVSM(I) = 2
 1150 CONTINUE
C
      GO TO 9990
C
 1900 CONTINUE
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE WERMS
C
C*******************************************************************
C
C  WEATHER DATA READING MASTER SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*******************************************************************
C
      NAMELIST /WERMSD/ TIHSAV, TIUSAV, TODBAV
C
      DOUBLE PRECISION FILNAM
C
      INCLUDE 'CAL.COM'
      COMMON /  CALI/ IDTOM(365)
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'TIDB.COM'
      COMMON / TIDBI/ TIDBM(12)
      COMMON / TIDBO/ TIHSAV, TIUSAV
      INCLUDE 'WE.COM'
      COMMON /   WEI/ TODBMX(365), TODBMN(365), TODBAM(365)
      COMMON /   WEO/ TODBAV
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(73)
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FAVG(A, B) = 0.5 * (A + B)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(NLOC .EQ. 1) FILNAM = 'FEWE.DAT'
      IF(NLOC .EQ. 2) FILNAM = 'GLWE.DAT'
      IF(NLOC .EQ. 3) FILNAM = 'FHWE.DAT'
      IF(NLOC .EQ. 4) FILNAM = 'PMWE.DAT'
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE=FILNAM)
C
      IX = IDAY1 - 1
      IF(IX .LT. 1) GO TO 1011
C
      DO 1010 I = 1, IX
         READ(50, 5000) DUMA
 5000       FORMAT(A1)
 1010 CONTINUE
 1011 CONTINUE
C
      DO 1050 I = 1,3
         DDUMA(I) = 0.
 1050 CONTINUE
C
      DO 1100 I = 1, NBPDYS
         IA = IDAY1 + I - 1
         IMNTHX = IDTOM(IA)
         TIDB = TIDBM(IMNTHX)
         READ(50, *) IY, TODBMX(IA), TODBMN(IA)
         TODBAM(IA) = FAVG(TODBMX(IA), TODBMN(IA))
         DDUMA(1) = TIDB + DDUMA(1)
         DDUMA(2) = FAVG(TODBAM(IA), TIDB) + DDUMA(2)
         DDUMA(3) = TODBAM(IA) + DDUMA(3)
 1100 CONTINUE
C
      ABPDYS = FLOAT(NBPDYS)
      TIHSAV = DDUMA(1) / ABPDYS
      TIUSAV = DDUMA(2) / ABPDYS
      TODBAV = DDUMA(3) / ABPDYS
```

```
      IF(IY .NE. IDAY2) GO TO 1900
      IF(IPRNT(20) .NE. 1) GO TO 9990
      GO TO 1920
C
 1900 CONTINUE
      WRITE(IWRITE, 6000) IY, IDAY2
 6000    FORMAT(//5X, 'IY .NE. IDAY2 IN WERMS.',
     8            //20X, '    IY = ', I6,
     8            /20X,  ' IDAY2 = ', I6, //)
C
 1920 CONTINUE
      WRITE(IWRITE, WERMSD)
C
 9990 CONTINUE
      CLOSE (UNIT=50)
      RETURN
      END
```

```
      SUBROUTINE WHR
C
C*****************************************************************
C
C  WATER HEATER INPUT DATA READING SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*****************************************************************
C
C  REFERENCES:
C
C     1. A.D. LITTLE PAPER.
C
C     2. _____. STUDY OF ENERGY SAVING OPTIONS FOR REFRIGERATORS
C        & WATER HEATERS.  A. D. LITTLE.  MAY 1977.
C
C*****************************************************************
C
C  NOTES:
C
C     1. NOMINAL NAMEPLATE CAPACITY IS SCALED DOWN TO PRODUCE
C        NET WATER STORAGE CAPACITY PER EXAMPLE IN REF 1.
C
C*****************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'WH.COM'
      COMMON /  WHIE/ IWHE, IWHLE, WHCAPE
      COMMON /  WHIG/ IWHNG, IWHLG, WHCAPG, IWHPLT
      COMMON /  WHOE/ WHBPE, WHVNE
      COMMON /  WHOG/ WHBPG, WHPPG, WHVNG
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
C--START EXECUTABLE STATEMENTS.
C
      OPEN(UNIT=50, DEVICE='DSK',ACCESS='SEQIN',FILE='WH.DAT')
C
 1050 CONTINUE
      READ(50,*, END = 1900) IY, (DDUMA(JA), JA = 1,3)
      IF(DDUMA(1) .EQ. 'NG') READ(50, *) DDUMA(4)
      IF(IY .NE. NRES) GO TO 1050
C
      IF(DDUMA(1) .EQ. 'E') GO TO 1100
      IWHNG = 1
      WHCAPG = DDUMA(2)
      WHVNG = 38.6 / 40.  * WHCAPG
      IWHLG = 1
      IF(DDUMA(3) .EQ. 'U') IWHLG = 2
      IWHPLT = 1
      IF(DDUMA(4) .EQ. 'AID') IWHPLT = 2
C
C--TYPICAL GAS WATER HEATER IS 40 GAL. 45000 BTU/H MAIN BURNER POWER.
C--    700 BTU/H PILOT LIGHT POWER (REF 1 & 2).
C
      WHBPG = WHCAPG / 40. * 45000.
      WHPPG = WHCAPG / 40. * 700.
      GO TO 9990
C
 1100 CONTINUE
      IWHE = 1
      WHCAPE = DDUMA(2)
      WHVNE = 38.6 / 40. * WHCAPE
      IWHLE = 1
      IF(DDUMA(3) .EQ. 'U') IWHLE = 2
```

```
      C
      C--TYPICAL ELECTRIC WATER HEATER IS 52 GAL WITH 9000 W OF
      C--    BURNER POWER PER REF 1 & 2.
      C
            WHBPE = WHCAPE / 52. * 9000.
            GO TO 9990
      C
       1900 CONTINUE
      C
       9990 CONTINUE
            CLOSE (UNIT=50)
            RETURN
            END
```

APPENDIX A

CONSUMPTION SUBROUTINE LISTINGS

```
      SUBROUTINE APCMS
C
C***********************************************************************
C
C  APPLIANCE ENERGY CONSUMPTION MASTER SUBROUTINE.
C
C  R. J. RETTBERG  20 SEPT 1979.
C
C***********************************************************************
C
      INCLUDE 'ACONH.COM'
      COMMON / ACONH/ CWCHA, CWCHHS, CWCHUS, DWCHA, HWCHA
      INCLUDE 'BCONH.COM'
      COMMON / BCONH/ BLCHA
      INCLUDE 'TCONH.COM'
      COMMON / TCONH/ TCH
C
C--START EXECUTABLE STMTS.
C
C--CALCULATE AVERAGE MONTHLY SCALE FACTORS.
C
      CALL APMSFA
C
C--CALCULATE AVERAGE SUNRISE & SUNSET TIMES.
C
      CALL SRSSA
C
C--CALCULATE BASELOAD CONSUMPTION.
C
      CALL BLCE
      CALL BLCN
      CALL BLCH
C
C--CALCULATE APPLIANCE ELECTRICITY CONSUMPTION.
C
      CALL APCEMS
C
C--CALCULATE APPLIANCE NATURAL GAS CONSUMPTION.
C
      CALL APCNMS
C
C--CALCULATE APPLIANCE WATER CONSUMPTION.
C
      CALL APCHMS
C
C--CALCULATE WATER HEATER ENERGY CONSUMPTION.
C
C--   CALCULATE TOTAL WATER CONSUMPTION.
C
      TCH = BLCHA + CWCHA + DWCHA + HWCHA
C
C--   CALCULATE THE WATER HEATER ELECTRICITY CONSUMPTION.
C
      CALL WHCE
C
C--   CALCULATE WATER HEATER NATURAL GAS CONSUMPTION.
C
      CALL WHCN
C
C--CALCULATE TOTAL ELECTRICITY & NATURAL GAS CONSUMPTION.
C
      CALL APCTOT
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE APCEMS
C
C************************************************************************
C
C  APPLIANCE (EXCEPT WATER HEATER) ELECTRICITY CONSUMPTION
C  MASTER SUBROUTINE.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C************************************************************************
C
C
C--START EXECUTABLE STMTS.
C
      CALL CDCE
      CALL CWCE
      CALL DWCE
      CALL FRCE
      CALL LICE
      CALL RECE
      CALL ROCE
      CALL TVCE
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE APCHMS
C
C*******************************************************************
C
C  APPLIANCE WATER CONSUMPTION MASTER SUBROUTINE.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*******************************************************************
C
C
C--START EXECUTABLE STMTS.
C
      CALL CWCH
      CALL DWCH
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE APCNMS
C
C*****************************************************************************
C
C  APPLIANCE (EXCEPT WATER HEATER) NATURAL GAS CONSUMPTION
C  MASTER SUBROUTINE.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************************
C
C
C--START EXECUTABLE STMTS.
C
      CALL CDCN
      CALL ROCN
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE APCTOT
C
C************************************************************************
C
C  APPLIANCE TOTAL ENERGY CONSUMPTION CALCULATIONS.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C************************************************************************
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
      INCLUDE 'ACONH.COM'
      COMMON / ACONH/ CWCHA, CWCHHS, CWCHUS, DWCHA, HWCHA
      INCLUDE 'ACONN.COM'
      COMMON / ACONN/ CDCNA, CDCNHS, CDCNUS, ROCNA, SUCNA,
     &                OVCNA, WHCNA
C
      INCLUDE 'BCONE.COM'
      COMMON / BCONE/ BLCEA
      INCLUDE 'BCONH.COM'
      COMMON / BCONH/ BLCHA
      INCLUDE 'BCONN.COM'
      COMMON / BCONN/ BLCNA, BLCNHS, BLCNUS, BLCNCP,
     &                BLCNFP, BLCNSP, BLCNOP, BLCNWP
C
      INCLUDE 'TCONE.COM'
      COMMON / TCONE/ TCENWH, TCEWWH
      INCLUDE 'TCONH.COM'
      COMMON / TCONH/ TCH
      INCLUDE 'TCONN.COM'
      COMMON / TCONN/ TCNNWH, TCNWWH
C
C--START EXECUTABLE STMTS.
C
C--DO ELECTRIC W/O WATER HEATER.
C
      TCENWH = CDCEA + CWCEA + DWCEA + FRCEA + ALICEA +
     &         RECEA + ROCEA + TVCEA + BLCEA
C
C--DO NATURAL GAS W/O WATER HEATER.
C
      TCNNWH = CDCNA + ROCNA + BLCNA
C
C--ADD WATER HEATER CONSUMPTION.
C
      TCEWWH = TCENWH + WHCEA
      TCNWWH = TCNNWH + WHCNA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BLCE
C
C***************************************************************************
C
C  ELECTRICITY CONSUMPTION FOR BASELOAD APPLIANCES, ETC.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C***************************************************************************
C
      REAL KWHPY, KWHPD
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
C
      INCLUDE 'OC.COM'
      COMMON /    OCI/ NOCC
C
      INCLUDE 'WHMSF.COM'
      COMMON /WHMSFS/ WHMSFA, WHMSF(12)
C
      INCLUDE 'BCONE.COM'
      COMMON / BCONE/ BLCEA
C
C--535 KWH / Y BASED ON CONSUMPTION/SATURATION OF MISCELLANEOUS
C--    APPLIANCES.
C
      DATA  KWHPY/ 535./
      DATA IENTER/ 1/
C
C--USE WATER CONSUMPTION SCALE FACTOR FOR BASELOAD ELECTRICITY.
C
C--INTERNAL FUNCTIONS.
C
      FBLE4N(NOCC) = (5.095 + 1.804 * NOCC) / (5.095 + 1.804 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO  KWH / DAY.
C
      KWHPD = KWHPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      BLCEA = KWHPD * FBLE4N(NOCC) * WHMSFA * FLOAT(NBPDYS)
C
 9990 CONTINUE
      RETURN
      END
```

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```
      SUBROUTINE BLCH
C
C*****************************************************************
C
C  WATER CONSUMPTION FOR BASELOAD APPLIANCES, SHOWERS,
C     ETC.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************
C
C  REFERENCES:
C
C     1. SAI CW, CD, DW  REPT TO DOE.  P 4-51.
C
C     2. DOE STANDARD FOR CW FR AEP FR FOR CERCDC P 3-37.
C
C     3. DOE STANDARD FOR WH FR REF 2:  P 3-91.
C
C     4. REF 1:  P3-70.
C
C*****************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'WHMSF.COM'
      COMMON /WHMSFS/ WHMSFA, WHMSF(12)
C
      INCLUDE 'BCONH.COM'
      COMMON / BCONH/ BLCHA
C
C--ASSUME 330 GAL / WEEK TOTAL (REF. 3) (revised).
C
      DATA CPW/ 330./
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FBLH4N(NOCC) = (5.095 + 1.804 * NOCC) / (5.095 + 1.804 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF (IENTER .GT. 1) GO TO 1050
      GPY = 52. * GPW
C
C--SUBTRACT OUT CLOTHES WASHER @ 17 GAL/LOAD (REF. 1)
C--    & 34 LOADS/MONTH (REF. 2).
C
      GPYN = GPY - 17. * 34. * 12.
C
C--SUBTRACT OUT DISHWASHER @ 15.7 GAL/LOAD & 8 LOADS/WEEK
C--    (REF. 4).
C
      GPYN = GPYN - 15.7 * 8. * 52.
C
C--CONVERT TO GALLONS PER DAY.
C
      CPDN = GPYN / 365.
      IENTER = 2
C
 1050 CONTINUE
C
      BLCHA = CPDN * FBLH4N(NOCC) * WHMSFA * FLOAT(NBPDYS)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BLCN
C
C******************************************************************
C
C  NATURAL GAS CONSUMPTION FOR BASELOAD APPLIANCES, ETC.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C******************************************************************
C
      NAMELIST / BLCND/ CDPPG, FUPPG, SUPPG, OVPPG, WHPPG,
     &                  BLCNA, BLCNHS, BLCNUS, BLCNCP,
     &                  BLCNFP, BLCNSP, BLCNOP, BLCNWP
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'CD.COM'
      COMMON /  CDIE/ ICDE, ICDLE
      COMMON /  CDIG/ ICDNG, ICDLG, ICDPLT
      COMMON /  CDOG/ CDPPG
      INCLUDE 'FU.COM'
      COMMON /  FUIE/ IFUE
      COMMON /  FUIG/ IFUNG, FUBPG, IFUPLT
      COMMON /  FUOG/ IFUPOO(2), FUPPG
      INCLUDE 'RO.COM'
      COMMON /  SUIE/ ISUE
      COMMON /  SUIG/ ISUNG, NSUPLS, ISUPLT
      COMMON /  OVIE/ IOVE
      COMMON /  OVIG/ IOVNG, NOVPLS, IOVPLT
      COMMON /  SUOG/ SUPPG
      COMMON /  OVOG/ OVPPG
      INCLUDE 'WH.COM'
      COMMON /  WHIE/ IWHE, IWHLE, WHCAPE
      COMMON /  WHIG/ IWHNG, IWHLG, WHCAPG, IWHPLT
      COMMON /  WHOE/ WHBPE, WHVNE
      COMMON /  WHOG/ WHBPG, WHPPG, WHVNG
C
      INCLUDE 'BCONN.COM'
      COMMON / BCONN/ BLCNA, BLCNHS, BLCNUS, BLCNCP,
     &                BLCNFP, BLCNSP, BLCNOP, BLCNWP
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      BLCNA  = 0.
      BLCNHS = 0.
      BLCNUS = 0.
      BLCNCP = 0.
      BLCNFP = 0.
      BLCNSP = 0.
      BLCNOP = 0.
      BLCNWP = 0.
      ABPDYS = FLOAT(NBPDYS)
C
C--WATER HEATER STANDING PILOT LIGHT.
C
      IF( IWHE  .EQ. 1)  GO TO 1100
      IF( IWHNG .NE. 1)  GO TO 1100
      IF( IWHPLT .EQ. 2) GO TO 1100
      BLCNWP = WHPPG * 24. * ABPDYS
C
C--      ASSUME 70 % WH PILOT BTU ENTERS THE SURROUNDING SPACE.
C
      IF( IWHLG .EQ. 1) BLCNHS = 0.70 * BLCNWP
      IF( IWHLG .EQ. 2) BLCNUS = 0.70 * BLCNWP
C
 1100 CONTINUE
C
C--CLOTHES DRYER STANDING PILOT LIGHT.
```

```
C
      IF(ICDE .EQ. 1) GO TO 1200
      IF(ICDNG .NE. 1) GO TO 1200
      IF(ICDPLT .EQ. 2) GO TO 1200
      BLCNCP = CDPPG * ABPDYS * 24.
C
C--      ASSUME 70 % CD PILOT BTU ENTERS THE SURROUNDING SPACE.
C
      IF(ICDLG .EQ. 1)BLCNHS = BLCNHS + 0.70 * BLCNCP
      IF(ICDLG .EQ. 2)BLCNUS = BLCNUS + 0.70 * BLCNCP
C
 1200 CONTINUE
C
C--RANGE 3 OVEN STANDING PILOT LIGHTS.
C
      IF(ISUE .EQ. 1) GO TO 1350
      IF(ISUPLT .EQ. 2) GO TO 1350
      BLCNSP = SUPPG * FLOAT(NSUPLS) * ABPDYS * 24.
C
C--      ASSUME 100 % SU PILOT BTU ENTERS THE SURROUNDING HEATED SPACE.
C
      BLCNHS = BLCNHS + BLCNSP
C
 1350 CONTINUE
      IF(IOVE .EQ. 1) GO TO 1400
      IF(IOVPLT .EQ. 2) GO TO 1400
      BLCNOP = OVPPG * FLOAT(NOVPLS) * ABPDYS * 24.
C
C--      ASSUME 100 % OV PILOT BTU ENTERS THE SURROUNDING HEATED SPACE.
C
      BLCNHS = BLCNHS + BLCNOP
C
 1400 CONTINUE
C
C--FURNACE STANDING PILOT LIGHT.
C
      NDYSON = 0
      IF(IFUE .EQ. 1) GO TO 1700
      IF(IFUNG .NE. 1) GO TO 1700
      IF(IFUPLT .EQ. 2) GO TO 1700
      IDUMA = IFUPOO(2) - IFUPOO(1)
      IF(IDUMA .LT. 0) GO TO 1450
      IF(IDAY1 .GE. IFUPOO(2)) GO TO 1700
      IDUMA = MIN0(IDAY2 + 1, IFUPOO(2))
      IDUMB = MAX0(IDAY1, IFUPOO(1))
      NDYSON = IDUMA - IDUMB
      GO TO 1480
C
 1450 CONTINUE
      IDUMA = MIN0(IDAY2 + 1, IFUPOO(2))
      NDYSON = MAX0(0, IDUMA - IDAY1)
      IDUMA = MAX0(IDAY1, IFUPOO(1))
      IF(IDAY2 .GT. IDUMA) NDYSON = NDYSON + IDAY2 + 1
     &                                  - IDUMA
C
 1480 CONTINUE
      BLCNFP = FUPPG * FLOAT(NDYSON) * 24.
C
 1700 CONTINUE
      BLCNA = BLCNCP + BLCNFP + BLCNSP + BLCNOP + BLCNWP
C
      IF(IPRNT(25) .NE. 1) GO TO 9990
      WRITE(IWRITE, BLCND)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CDCE
C
C***********************************************************************
C
C  CLOTHES DRYER ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C***********************************************************************
C
C  REFERENCES:
C
C      1. SAI CW, CD, DW DOE REPT P 5-39.
C
C      2. DOE STANDARDS.
C
C      3. REF. 1:  P 5-34.
C
C***********************************************************************
C
      REAL KWHPY, KWHPD, KWHPL
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                    IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'CDMSF.COM'
      COMMON /CDMSFS/ CDMSFA, CDMSF(12)
C
      INCLUDE 'CD.COM'
      COMMON /  CDIE/ ICDE, ICDLE
      COMMON /  CDIG/ ICDNG, ICDLG, ICDPLT
      COMMON /  CDOG/ CDPPG
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--KWH / LOAD FROM REF. 1.
C
      DATA KWHPL/ 2.32/
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FCDE4N(NOCC) = (0.526 + 0.603 * NOCC) / (0.526 + 0.603 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF( IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO KWH PER DAY.
C--   ASSUME 34 LOADS / MONTH (REF. 2).
C
      KWHPY = KWHPL * 34. * 12.
      KWHPD = KWHPY / 365.
      IENTER = 2
C
 1050 CONTINUE
```

```
      CDCEA = 0.
      CDCEHS = 0.
      CDCEUS = 0.
      IF(ICDE .NE. 1) GO TO 9990
      CDCEA = KWHPD * FCDE4N(NOCC) * CDMSFA * FLOAT(NBPDYS)
C
C--ASSUME 16 % OF ELECTRIC CD ENERGY CONSUMPTION ENTERS THE
C--   SPACE SURROUNDING THE CD (REF. 3).
C
      IF(ICDLE .EQ. 1) CDCEHS = 0.16 * CDCEA
      IF(ICDLE .EQ. 2) CDCEUS = 0.16 * CDCEA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CDCN
C
C*****************************************************************************
C
C  CLOTHES DRYER NATURAL GAS CONSUMPTION.
C
C  R. J. RETTBERG    25 SEPT 1979.
C
C*****************************************************************************
C
C  REFERENCES:
C
C      1. NN MONTHLY REPT IN TURN FROM GAS FACTS.
C         *** ASSUMES AID ***. THEREFORE MAIN
C         BURNER CONSUMPTION ONLY.
C
C      2. SAI CW, CD, DW DOE REPT:  P 5-39.
C
C      3. DOE STANDARDS.
C
C      4. REF. 2:  P 5-34.
C
C*****************************************************************************
C
      REAL KWHPY, KWHPD, KWHPL
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /    OCI/ NOCC
C
      INCLUDE 'CDMSF.COM'
      COMMON /CDMSFS/ CDMSFA, CDMSF(12)
C
      INCLUDE 'CD.COM'
      COMMON /   CDIE/ ICDE, ICDLE
      COMMON /   CDIG/ ICDNG, ICDLG, ICDPLT
      COMMON /   CDOG/ CDPPG
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     8                DWCEA, FRCEA, FRCEHS, FRCEUS,
     8                ALICEA, ALICEO, ALICEH,
     8                RECEA, RECEHS, RECEUS,
     8                ROCEA, SUCEA, OVCEA, TVCEA,
     8                WHCEA, WHCEHS, WHCEUS, WHCEI
      INCLUDE 'ACONN.COM'
      COMMON / ACONN/ CDCNA, CDCNHS, CDCNUS, ROCNA, SUCNA,
     8                OVCNA, WHCNA
C
      INCLUDE 'FFEN.COM'
      COMMON / FFENI/ BTUPCF, BTUPGO
C
C--NOMINAL CF & KWH / LOAD FROM REFERENCE 2.
C--   THE CF / LOAD EXCLUDES THE PILOT LIGHT.
C
      DATA CFPL/ 7.6/
      DATA KWHPL / 0.11/
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FCDN4N(NOCC) = (0.526 + 0.603 * NOCC) / (0.526 + 0.603 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO BTU PER DAY AND KWH PER DAY.
C--   ASUME 34 LOADS / MONTH PER REF. 3.
C
      CFPY = CFPL * 34. * 12.
```

```
      CFPD = CFPY / 365.
      BTUPD = CFPD * BTUPCF
C
      KWHPY = KWHPL * 34. * 12.
      KWHPD = KWHPY / 365.
      IENTER = 2
C
 1050 CONTINUE
C
C--DO NATURAL GAS.
C
      CDCNA = 0.
      CDCNHS = 0.
      CDCNUS = 0.
      IF(ICDNG .NE. 1) GO TO 9990
      CDCNA = BTUPD * FCDN4N(NOCC) * CDMSFA * FLOAT(NBPDYS)
C
C--   ASSUME 16 % OF THE MAIN BURNER NG CONSUMPTION ENTERS
C--      THE SURROUNDING SPACE (REF. 4).
C
      IF(ICDLG .EQ. 1) CDCNHS = 0.16 * CDCNA
      IF(ICDLG .EQ. 2) CDCNUS = 0.16 * CDCNA
C
C--DO ELECTRICITY.
C
      CDCEA = 0.
      CDCEHS = 0.
      CDCEUS = 0.
      CDCEA = KWHPD * FCDN4N(NOCC) * CDMSFA * FLOAT(NBPDYS)
C
C--   ASSUME 16 % OF THE ELECTRIC MOTOR ENERGY CONSUMPTION ENTERS
C--      THE SURROUNDING SPACE (REF. 4).
C
      IF(ICDLG .EQ. 1) CDCEHS = 0.16 * CDCEA
      IF(ICDLG .EQ. 2) CDCEUS = 0.16 * CDCEA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CWCE
C
C***************************************************************************
C
C  CLOTHES WASHER ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C***************************************************************************
C
C  REFERENCES:
C
C      1. SAI CW, CD, DW DOE REPT:  P 4-51.
C
C      2. DOE STANDARDS.
C
C***************************************************************************
C
      REAL KWHPY, KWHPD, KWHPL
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /    OCI/ NOCC
C
      INCLUDE 'CWMSF.COM'
      COMMON /CWMSFS/ CWMSFA, CWMSF(12)
C
      INCLUDE 'CW.COM'
      COMMON /   CWIE/ ICWE, ICWLE
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--ASSUME 0.2 KWH / LOAD (REF. 1).
C
      DATA KWHPL/ 0.200/
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FCWE4N(NOCC) = (-0.0016 + 0.0672 * NOCC) / (-0.0016 + 0.0672 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO KWH PER DAY.
C--   ASSUME 34 LOADS / MONTH (REF. 2).
C
      KWHPY = KWHPL * 34. * 12.
      KWHPD = KWHPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      CWCEA = 0.
      CWCEHS = 0.
      CWCEUS = 0.
      IF(ICWE .NE. 1) GO TO 9990
      CWCEA = KWHPD * FCWE4N(NOCC) * CWMSFA * FLOAT(NBPDYS)
      IF(ICWLE .EQ. 1) CWCEHS = CWCEA
      IF(ICWLE .EQ. 2) CWCEUS = CWCEA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CWCH
C
C*************************************************************************
C
C  CLOTHES WASHER HOT WATER CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*************************************************************************
C
C  REFERENCES:
C
C      1. SAI CW, CD, DW DOE REPT:  P 4-31.
C
C      2. DOE STANDARDS.
C
C*************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'CWMSF.COM'
      COMMON /CWMSFS/ CWMSFA, CWMSF(12)
C
      INCLUDE 'CW.COM'
      COMMON /  CWIE/ ICWE, ICWLE
C
      INCLUDE 'ACONH.COM'
      COMMON / ACONH/ CWCHA, CWCHHS, CWCHUS, DWCHA, HWCHA
C
C--ASSUME 17 GAL / LOAD (REF. 1).
C
      DATA GPL/ 17./
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FCWH4N(NOCC) = (-0.0016 + 0.0672 * NOCC) / (-0.0016 + 0.0672 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO GALLONS / DAY BASED ON 34 LOADS/MONTH (REF. 2).
C
      GPY = GPL * 34. * 12.
      GPD = GPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      CWCHA = 0.
      CWCHHS = 0.
      CWCHUS = 0.
      IF(ICWE .NE. 1) GO TO 9990
      CWCHA = GPD * FCWH4N(NOCC) * CWMSFA * FLOAT(NBPDYS)
      IF(ICWLE .EQ. 1) CWCHHS = CWCHA
      IF(ICWLE .EQ. 2) CWCHUS = CWCHA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DWCE
C
C*****************************************************************************
C
C  DISHWASHER ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************************
C
C  REFERENCES:
C
C     1. SAI CW, CD, DW DOE REPT:  P 3-70.
C
C*****************************************************************************
C
      REAL KWHPL, KWHPY, KWHPD
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                   IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'DWMSF.COM'
      COMMON /DWMSFS/ DWMSFA, DWMSF(12)
C
      INCLUDE 'DW.COM'
      COMMON /  DWIE/ IDWE
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     8                DWCEA, FRCEA, FRCEHS, FRCEUS,
     8                ALICEA, ALICEO, ALICEH,
     8                RECEA, RECEHS, RECEUS,
     8                ROCEA, SUCEA, OVCEA, TVCEA,
     8                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--ASSUME 0.740 KWH / LOAD (REF. 1).
C
      DATA KWHPL/ 0.740/
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FDWE4N(NOCC) = (0.04 + 0.089 * NOCC) / (0.04 + 0.089 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO KWH PER DAY BASED ON 8 LOADS / WEEK (REF. 1).
C
      KWHPY = KWHPL * 8. * 52.
      KWHPD = KWHPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      DWCEA = 0.
      IF(IDWE .NE. 1) GO TO 9990
      DWCEA = KWHPD * FDWE4N(NOCC) * DWMSFA * FLOAT(NBPDYS)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DWCH
C
C************************************************************************
C
C  DISHWASHER HOT WATER CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C************************************************************************
C
C  REFERENCES:
C
C      1. SAI CW, CD, DW DOE REPT:  P 3-70.
C
C************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                 IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /    OCI/ NOCC
C
      INCLUDE 'DWMSF.COM'
      COMMON /DWMSFS/ DWMSFA, DWMSF(12)
C
      INCLUDE 'DW.COM'
      COMMON /   DWIE/ IDWE
C
      INCLUDE 'ACONH.COM'
      COMMON / ACONH/ CWCHA, CWCHHS, CWCHUS, DWCHA, HWCHA
C
C--ASSUME 15.7 GAL / LOAD (REF. 1).
C
      DATA GPL/ 15.7/
      DATA IENTER/ 1/
C
      FDWH4N(NOCC) = (0.04 + 0.089 * NOCC) / (0.04 + 0.089 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO GAL / DAY @ 8 LOADS / WEEK (REF. 1).
C
      GPY = GPL * 8. * 52.
      GPD = GPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      HWCHA = 0.
      DWCHA = GPD * FDWH4N(NOCC) * DWMSFA * FLOAT(NBPDYS)
      IF(IDWE .EQ. 1) GO TO 9990
C
C--ASSUME HAND WASHING REQUIRES 50% OF DISHWASHER HOT WATER
C--    REQUIREMENTS.
C
      HWCHA = DWCHA / 2.
      DWCHA = 0.
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FRCE
C
C***********************************************************************
C
C  FREEZER ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C***********************************************************************
C
C  REFERENCES:
C
C      1. SAI AEP FINAL REPT FOR CERCDC (3/76):  P 3-72.
C       . (THIS IS STANDARD FOR PURE FREEZERS PER DOE & AHAM .
C
C***********************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'FRMSF.COM'
      COMMON /FRMSFS/ FRMSFA, FRMSF(12)
C
      INCLUDE 'FR.COM'
      COMMON /  FRIE/ IFRE, IFRLE, FRPE
      INCLUDE 'TIDB.COM'
      COMMON / TIDBI/ TIDBM(12)
      COMMON / TIDBO/ TIHSAV, TIUSAV
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--START EXECUTABLE STMTS.
C
      FRCEA = 0.
      FRCEHS = 0.
      FRCEUS = 0.
      ABPDYS = FLOAT(NBPDYS)
      IF(IFRE .NE. 1) GO TO 9990
C
      IF(IFRLE .EQ. 2)GO TO 1200
C
C--FREEZER IN HEATED SPACE.
C
      FRCEHS = FRPE * 12. / 365. * FRMSFA * ABPDYS
      GO TO 1700
C
 1200 CONTINUE
C
C--FREEZER IN UNHEATED SPACE.
C
C--    ASSUME THE FREEZER TEMPERATURE IS 0.0 DEG-F (REF. 1).
C
      DUMA = TIUSAV / 73.
      IF(DUMA .LT. 0.) DUMA = 0.
      FRCEUS = DUMA * FRPE * 12. / 365. * FRMSFA * ABPDYS
C
 1700 CONTINUE
      FRCEA = FRCEUS + FRCEHS
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LICE
C
C*****************************************************************************
C
C  LIGHTING ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************************
C
      NAMELIST / LICED/ AMWMAX, AMWHPD, PMWMAX, PMWHPD,
     &                  ODHPD, ODPEI, ODPEF, ODWHPD,
     &                  ALICEA, ALICEO, ALICEH
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'SUN.COM'
      COMMON /  SUNI/ SRTIM(4, 12), SSTIM(4, 12)
      COMMON /  SUNO/ SRTIMA, SSTIMA
C
      INCLUDE 'LI.COM'
      COMMON / LIINR/ NBAR, NBER
      COMMON / LIISF/ ALTSF, AKSF, ALRSF, BASF(3), BESF(3),
     &                DENSF, DRSF, HWSF
      COMMON / LIIEI/ ALTPEI, AKPEI, ALRPEI, BAPEI(3), BEPEI(3),
     &                DENPEI, DRPEI, HWPEI, ODPEI
      COMMON / LIIEF/ ALTPEF, AKPEF, ALRPEF, BAPEF(3), BEPEF(3),
     &                DENPEF, DRPEF, HWPEF, ODPEF
      COMMON /LIIMIS/ ODHPD
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      ALICEA = 0.
      ALICEO = 0.
      ALICEH = 0.
      ODWHPD = 0.
      AMWMAX = 0.
      AMWHPD = 0.
      PMWMAX = 0.
      PMWHPD = 0.
C
      DO 1020 I = 1, 20
         DDUMA(I) = 0.
         DDUMB(I) = 0.
 1020 CONTINUE
C
C--DO AM CALCULATIONS.
C
```

```
      DDUMA(1) = 1. * (AKPEF + AKPEI)
      DDUMA(2) = 0.5 * (ALRPEF + ALRPEI)
      DDUMA(3) = 0.5 * (BAPEF(1) + BAPEI(1))
      IF(NBAR .GT. 1 .AND. NOCC .GE. 3)
     &      DDUMA(4) = 0.50 * (BAPEF(2) + BAPEI(2))
      IF(NBAR .GT. 2 .AND. NOCC .GE. 5)
     &      DDUMA(5) = 0.50 * (BAPEF(3) + BAPEI(3))
      DDUMA(6) = 0.5 * (BEPEF(1) + BEPEI(1))
      IF(NBER .GT. 1 .AND. NOCC .GE. 3)
     &      DDUMA(7) = 0.50 * (BEPEF(2) + BEPEI(2))
      IF(NBER .GT. 2 .AND. NOCC .GE. 5)
     &      DDUMA(8) = 0.50 * (BEPEF(3) + BEPEI(3))
      IF(NBER .GT. 3 .AND. NOCC .GE. 7)
     &      DDUMA(9) = 0.50 * (BEPEF(4) + BEPEI(4))
      IF(NBER .GT. 4 .AND. NOCC .GE. 9)
     &      DDUMA(10) = 0.50 * (BEPEF(5) + BEPEI(5))
      DDUMA(11) = 1. * (DRPEF + DRPEI)
      DDUMA(12) = 0.30 * (HWPEF + HWPEI)
C
      DO 1050 I = 1, 20
         AMWMAX = AMWMAX + DDUMA(I)
 1050 CONTINUE
C
      IF(SRTIMA + 1. .LT. 6.5) GO TO 1075
      AMWHPD = AMWMAX * (SRTIMA + 1. - 6.5)
      AMWHPD = AMWHPD + 0.5 * AMWMAX
      GO TO 1100
C
 1075 CONTINUE
      TON = AMAX1(0., SRTIMA + 2. - 6.5)
      AMWHPD = 0.5 * (TON ** 2) * AMWMAX
C
 1100 CONTINUE
C
C--DO PM CALCULATIONS.
C
      DDUMB(1) = 0.5 * (AKPEF + AKPEI)
      DDUMB(2) = 1.0 * (ALRPEF + ALRPEI)
      DDUMB(3) = 0.20 * (BAPEF(1) + BAPEI(1))
      IF(NBAR .GT. 1 .AND. NOCC .GE. 3)
     &      DDUMB(4) = 0.20 * (BAPEF(2) + BAPEI(2))
      IF(NBAR .GT. 2 .AND. NOCC .GE. 5)
     &      DDUMB(5) = 0.20 * (BAPEF(3) + BAPEI(3))
      DDUMB(6) = 0.20 * (BEPEF(1) + BEPEI(1))
      IF(NBER .GT. 1 .AND. NOCC .GE. 3)
     &      DDUMB(7) = 0.20 * (BEPEF(2) + BEPEI(2))
      IF(NBER .GT. 2 .AND. NOCC .GE. 5)
     &      DDUMB(8) = 0.20 * (BEPEF(3) + BEPEI(3))
      IF(NBER .GT. 3 .AND. NOCC .GE. 7)
     &      DDUMB(9) = 0.20 * (BEPEF(4) + BEPEI(4))
      IF(NBER .GT. 4 .AND. NOCC .GE. 9)
     &      DDUMB(10) = 0.20 * (BEPEF(5) + BEPEI(5))
      DDUMB(11) = 0.10 * (DENPEF + DENPEI)
      DDUMB(12) = 0.50 * (DRPEF + DRPEI)
      DDUMB(13) = 0.30 * (HWPEF + HWPEI)
C
      DO 1150 I = 1, 20
         PMWMAX = PMWMAX + DDUMB(I)
 1150 CONTINUE
C
      PMWHPD = 0.50 * PMWMAX
      PMWHPD = PMWHPD + (22.0 - SSTIMA) * PMWMAX
      PMWHPD = PMWHPD + 0.5 * 1.5 * PMWMAX
C
C--DO OUTDOOR LIGHTING FOR SPECIFIED HOURS / DAY.
C
      ODWHPD = (ODPEF + ODPEI) * ODHPD
C
C--CALCULATE KWH FOR THE BILLING PERIOD.
C
```

```
      ALICEA = (AMWHPD + PMWHPD + ODWHPD) * FLOAT(NBPDYS)
      ALICEA = ALICEA / 1000.
C
C--   DETERMINE THE HEATED SPACE LIGHTING FOR INTERNAL LOAD
C--      PURPOSES BY SUBTRACTING OUT THE OUTDOOR LIGHTING KWH.
C
      ALICEO = ODWHPD * FLOAT(NBPDYS) / 1000.
      ALICEH = ALICEA - ALICEO
C
      IF(IPRNT(32) .NE. 1) GO TO 1900
      WRITE(IWRITE, LICED)
C
 1900 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RECE
C
C************************************************************************
C
C  REFRIGERATOR ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG    25 SEPT 1979.
C
C************************************************************************
C
C  REFERENCES:
C
C      1. SAI AEP FINAL REPT FOR CERCDC (3/76):  P 3-72.
C         (THIS IS STANDARD FOR R/F PER DOE & AHAM EXCEPT
C          FOR OLD U-CHANNEL TYPE THAT REALLY AREN'T FOOD
C          FREEZERS.).
C
C************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'REMSF.COM'
      COMMON /REMSFS/ REMSFA, REMSF(12)
C
      INCLUDE 'RE.COM'
      COMMON /  REIE/ NRE, IRELE(3), REPE(3)
      INCLUDE 'TIDB.COM'
      COMMON / TIDBI/ TIDBM(12)
      COMMON / TIDBO/ TIHSAV, TIUSAV
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--START EXECUTABLE STMTS.
C
      RECEA = 0.
      RECEHS = 0.
      RECEUS = 0.
      ABPDYS = FLOAT(NBPDYS)
C
C--SET THE TEMPERATURE SCALING FACTOR FOR REFRIGERATORS
C--    IN UNHEATED SPACES.
C
C--   ASSUME THE REFRIGERATOR AVERAGE TEMPERATURE IS
C--      THE AVERAGE OF THE STANDARD GRC TEMP OF 38 DEG-F
C--      (REF. 1) & THE STANDARD FREEZER COMPARTMENT TEMP
C--      OF 5 DEG-F (REF. 1) OR 21.50 DEG-F.
C
      DUMA = 21.50
      DUMA = (TIUSAV - DUMA) / (75. - DUMA)
      IF(DUMA .LT. 0.) DUMA = 0.
      IF(NRE .LT. 1) GO TO 9990
C
      DO 1500 I = 1, NRE
         IF(IRELE(I) .EQ. 2)GO TO 1200
C
C--REFRIGERATOR IN HEATED SPACE.
C
         RECEHS = REPE(I) * 12. / 365. * REMSFA * ABPDYS
     &            + RECEHS
         GO TO 1500
```

```
C
 1200    CONTINUE
C
C--REFRIGERATOR IN UNHEATED SPACE.
C
         RECEUS = DUMA * REPE(I) * 12. / 365. * REMSFA * ABPDYS
     8             + RECEUS
C
 1300 CONTINUE
 1301 CONTINUE
C
      RECEA = RECEHS + RECEUS
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ROCE
C
C**********************************************************************
C
C  RANGE & OVEN ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C**********************************************************************
C
C  REFERENCES:
C
C      1. SAI DOE R & O REPORT: TABLE 6-4; P 6-9.
C
C**********************************************************************
C
      REAL KWHPY, KWHPD
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'ROMSF.COM'
      COMMON /ROMSFS/ ROMSFA, ROMSF(12)
      COMMON /SUMSFS/ SUMSFA, SUMSF(12)
      COMMON /OVMSFS/ OVMSFA, OVMSF(12)
C
      INCLUDE 'RO.COM'
      COMMON /  SUIE/ ISUE
      COMMON /  SUIG/ ISUNG, NSUPLS, ISUPLT
      COMMON /  OVIE/ IOVE
      COMMON /  OVIG/ IOVNG, NOVPLS, IOVPLT
      COMMON /  SUOG/ SUPPG
      COMMON /  OVOG/ OVPPG
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--ASSUME 740. KWH / YEAR BASED ON REF. 1.
C
      DATA KWHPY/ 740./
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FRAE4N(NOCC) = (1.22 + 0.24 * NOCC) / (1.22 + 0.24 * 4)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO KWH/DAY.
C
      KWHPD = KWHPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      ROCEA = 0.
      SUCEA = 0.
      OVCEA = 0.
      IF(ISUE .NE. 1) GO TO 1200
C
C--SURFACE UNIT CONSUMPTION.
```

```
C
C--    ASSUME 50% RANGE CONSUMPTION IS FOR SURFACE UNITS BASED ON REF 1.
C
       SUCEA = 0.50 * KWHPD * FRAE4N(NOCC) * SUMSFA * FLOAT(NBPDYS)
C
  1200 CONTINUE
       IF(IOVE .NE. 1) GO TO 1300
C
C--OVEN CONSUMPTION.
C
C--    ASSUME 50% RANGE CONSUMPTION IS FOR OVENS BASED ON REF 1.
C
       OVCEA = 0.50 * KWHPD * FRAE4N(NOCC) * OVMSFA * FLOAT(NBPDYS)
C
  1300 CONTINUE
       ROCEA = SUCEA + OVCEA
C
  9990 CONTINUE
       RETURN
       END
```

```
      SUBROUTINE ROCN
C
C*****************************************************************************
C
C  RANGE & OVEN NATURAL GAS CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************************
C
C  REFERENCES:
C
C     1. SAI R & O DOE REPT:  TABLE 6-5; P 6-10.
C
C*****************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'ROMSF.COM'
      COMMON /ROMSFS/ ROMSFA, ROMSF(12)
      COMMON /SUMSFS/ SUMSFA, SUMSF(12)
      COMMON /OVMSFS/ OVMSFA, OVMSF(12)
C
      INCLUDE 'RO.COM'
      COMMON /  SUIE/ ISUE
      COMMON /  SUIG/ ISUNG, NSUPLS, ISUPLT
      COMMON /  OVIE/ IOVE
      COMMON /  OVIG/ IOVNG, NOVPLS, IOVPLT
      COMMON /  SUOG/ SUPPG
      COMMON /  OVOG/ OVPPG
C
      INCLUDE 'ACONN.COM'
      COMMON / ACONN/ CDCNA, CDCNES, CDCNUS, ROCNA, SUCNA,
     &                OVCNA, WHCNA
C
C
C--ASSUME ANNUAL CONSUMPTION BASED ON REF. 1 EXCLUDING PILOT
C--   LIGHTS.  2.26 MILLION BTU / YEAR INPUT FOR SURFACE UNITS.
C--   2.70 MILLION BTU / YEAR INPUT FOR OVENS.
C
C--NOTE:  **** THESE VALUES ASSUME 50/50 SURFACE UNIT / OVEN USAGE.
C--   DIFFERENT EFFICIENCIES CAUSE DIFFERENT INPUT VALUES.
C
      DATA SUBPY/ 2.26 E6/
      DATA OVBPY/ 2.70 E6/
      DATA IENTER/ 1/
C
C--DEFINE INTERNAL FUNCTIONS.
C
      FRAN4N(NOCC) = (1.22 + 0.24 * NOCC) / (1.22 + 0.24 * 4.)
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO BTU/DAY.
C
      SUBPD = SUBPY / 365.
      OVBPD = OVBPY / 365.
      IENTER = 2
C
 1050 CONTINUE
      ROCNA = 0.
      SUCNA = 0.
      OVCNA = 0.
      IF(ISUNG .NE. 1) GO TO 1200
C
C--SURFACE UNIT CONSUMPTION.
C
```

```
      SUCNA = SUBPD * FRAN4N(NOCC) * SUMSFA * FLOAT(NBPDYS)
C
 1200 CONTINUE
      IF(IOVNG .NE. 1) GO TO 1300
C
C--OVEN CONSUMPTION.
C
      OVCNA = OVBPD * FRAN4N(NOCC) * OVMSFA * FLOAT(NBPDYS)
C
 1300 CONTINUE
      ROCNA = SUCNA + OVCNA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE TVCZ
C
C*********************************************************************
C
C  TELEVISION ELECTRICITY CONSUMPTION.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*********************************************************************
C
C  REFERENCES:
C
C     1. SAI AEP CERCDC FINAL REPT:  P 3-82.
C
C*********************************************************************
C
      DIMENSION HRSPY(3), HRSPD(3)
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'TVMSF.COM'
      COMMON /TVMSFS/ TVMSFA, TVMSF(12)
C
      INCLUDE 'TV.COM'
      COMMON /  TVIE/ NTV, ICVSM(3), TVPE(3)
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--ASSUME SET # 1 IS "ON" 2280 HOURS / YEAR (REF. 1).
C--    ASSUME SET # 2 IS ON 1000 H / Y (NO REFERENCE).
C--    ASSUME SET # 3 IS ON 500 H / Y (NO REFERENCE).
C
      DATA HRSPY/ 2280., 1000., 500./
      DATA IENTER/ 1/
C
C--START EXECUTABLE STMTS.
C
      IF(IENTER .GT. 1) GO TO 1050
C
C--CONVERT TO HOURS PER DAY.
C
      DO 1020 I = 1, 3
         HRSPD(I) = HRSPY(I) / 365.
 1020 CONTINUE
C
      IENTER = 2
C
 1050 CONTINUE
      TVCEA = 0.
      IF(NTV .LT. 1) GO TO 1201
C
      DO 1200 I = 1, NTV
         TVCEA = TVCEA + TVPE(I) * HRSPD(I) / 1000. * FLOAT(NBPDYS)

 1200 CONTINUE
 1201 CONTINUE
C
      TVCEA = TVCEA * TVMSFA
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WHCE
C
C*****************************************************************************
C
C  WATER HEATER ELECTRICITY CONSUMPTION CALCULATIONS.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************************
C
C  REFERENCES:
C
C     1. A. D. LITTLE PAPER.
C
C     2. A. D. LITTLE R & WH REPT OF MAY 1977.
C
C*****************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'TIDB.COM'
      COMMON / TIDBI/ TIDBM(12)
      COMMON / TIDBO/ TIHSAV, TIUSAV
C
      INCLUDE 'WH.COM'
      COMMON /  WHIE/ IWHE, IWHLE, WHCAPE
      COMMON /  WHIG/ IWHNG, IWHLG, WHCAPG, IWHPLT
      COMMON /  WHOE/ WHBPE, WHVNE
      COMMON /  WHOG/ WHBPG, WHPPG, WHVNG
C
      INCLUDE 'TCONH.COM'
      COMMON / TCONH/ TCH
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
C
C--VARIABLES FOR THE DOE EQUATION FOR WH ENERGY CONSUMPTION IN
C--BTU (OF FUEL ENERGY) / DAY.
C
C--   ER        = RECOVERY EFFICIENCY IN % (100 % FOR ELECTRIC).
C--   S         = STANDBY LOSS (STANDING PILOT LIGHT ASSUMED) IN %.
C--   DTW       = TEMP H20 OUT - TEMP H20 IN
C
C--   ASSUMED VALUES BASED ON REF 1 & 2 FOR S, & 145 - 60 OR
C--      85 DEG-F FOR DTW.
C
      DATA ER    / 100./
      DATA S     / 1.54/
      DATA DTW   / 85./
C
C--CONSTANTS FOR THE DOE EQUATION FOR WH ENERGY CONSUMPTION IN
C--BTU (OF FUEL) / DAY (CONVERTED TO KWH @ THE END).
C
C--   CP        = H20 SPECIFIC HEAT IN BTU/GAL/DEG-F.
C--   HPD       = HOURS PER DAY.
C
      DATA CP  / 8.331/
      DATA HPD / 24./
C
C--START EXECUTABLE STMTS.
C
      WHCEA = 0.
      WHCEHS = 0.
      WHCEUS = 0.
      WHCEI = 0.
      IF(IWHE .NE. 1) GO TO 9990
```

```
      C
            ABPDYS = FLOAT(NBPDYS)
            GPD = TCH / ABPDYS
            TWMTA = 143. - TIHSAV
            IF(IWHLE .EQ. 2) TWMTA = 145. - TIUSAV
      C
            BTUPDT = (100. / ER) * CP * GPD * DTW
            DUMA = (CP * GPD * DTW) / (HPD * 3.413 * WHBPE * (ER / 100.))
            DUMA = 1. - DUMA
            BTUPDT = BTUPDT + HPD * CP * WHVNE * TWMTA * (S / 100.) * DUMA
            WHCEA = BTUPDT * ABPDYS
            WHCEA = WHCEA / 3413.
      C
      C--   ASSUME EXCESS ENERGY CONSUMPTION OVER "IDEAL" ENTERS
      C--      THE SURROUNDING SPACE.
      C
      C--   BTUID = IDEAL BTU REQUIRED TO RAISE THE DAILY CONSUMPTION
      C--      DTW DEGREES.
      C
            BTUID = GPD * CP * DTW * ABPDYS
            WHCEI = BTUID / 3413.
            DUMA = WHCEA - WHCEI
            IF(IWHLE .EQ. 1) WHCEHS = DUMA
            IF(IWHLE .EQ. 2) WHCEUS = DUMA
      C
       9990 CONTINUE
            RETURN
            END
```

```
      SUBROUTINE WHCN
C
C**********************************************************************
C
C  WATER HEATER NATURAL GAS CONSUMPTION CALCULATIONS.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C**********************************************************************
C
C  REFERENCES:
C
C     1. A. D. LITTLE PAPER.
C
C     2. A. D. LITTLE R & WH REPT OF MAY 1977.
C
C**********************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'TIDB.COM'
      COMMON / TIDBI/ TIDBM(12)
      COMMON / TIDBO/ TIHSAV, TIUSAV
C
      INCLUDE 'WH.COM'
      COMMON /  WHIE/ IWHE, IWHLE, WHCAPE
      COMMON /  WHIG/ IWHNG, IWHLG, WHCAPG, IWHPLT
      COMMON /  WHOE/ WHBPE, WHVNE
      COMMON /  WHOG/ WHBPG, WHPPG, WHVNG
C
      INCLUDE 'TCONH.COM'
      COMMON / TCONH/ TCH
C
      INCLUDE 'ACONN.COM'
      COMMON / ACONN/ CDCNA, CDCNHS, CDCNUS, ROCNA, SUCNA,
     &                OVCNA, WHCNA
C
      INCLUDE 'BCONN.COM'
      COMMON / BCONN/ BLCNA, BLCNHS, BLCNUS, BLCNCP,
     &                BLCNFP, BLCNSP, BLCNOP, BLCNWP
C
C--VARIABLES FOR THE DOE EQUATION FOR WH ENERGY CONSUMPTION IN
C--BTU (OF FUEL ENERGY) / DAY.
C
C--   ER         = RECOVERY EFFICIENCY IN %.
C--   S          = STANDBY LOSS (STANDING PILOT LIGHT ASSUMED) IN %.
C--   DTW        = TEMP H2O OUT - TEMP H2O IN
C
C--   ASSUMED VALUES BASED ON REF 1 & 2 FOR ER & S, & 145 - 60 OR
C--      85 DEG-F FOR DTW.
C
      DATA ER    / 72./
      DATA S     / 6./
      DATA DTW   / 85./
C
C--CONSTANTS FOR THE DOE EQUATION FOR WH ENERGY CONSUMPTION IN
C--BTU (OF FUEL) / DAY.
C
C--   CP         = H2O SPECIFIC HEAT IN BTU/GAL/DEG-F.
C--   HPD        = HOURS PER DAY.
C
      DATA CP  / 8.331/
      DATA HPD / 24./
C
C--START EXECUTABLE STMTS.
C
      WHCNA = 0.
      IF(IWHNG .NE. 1) GO TO 9990
C
```

```
      ABPDYS = FLOAT(NBPDYS)
      GPD = TCH / ABPDYS
      TWMTA = 145. - TIHSAV
      IF(IWHLG .EQ. 2) TWMTA = 145. - TIUSAV
C
      BTUPDT = (100. / ER) * CP * GPD * DTW
      DUMA = (CP * GPD * DTW) / (HPD * WHBPG * (ER / 100.))
      DUMA = 1. - DUMA
      BTUPDT = BTUPDT + HPD * CP * WHVNG * TWMTA * (S / 100.) * DUMA
C
C--MUST ASSUME A STANDING PILOT LIGHT IS PRESENT EVEN IF IT IS NOT
C--    BECAUSE THE NOMINAL VALUES USED TO MODEL THE WATER HEATER ASSUME
C--    A STANDING PILOT LIGHT. (????).
C
      WHCNA = BTUPDT * ABPDYS - BLCNWP
      IF(IWHPLT .EQ. 1) GO TO 9990
      BTUPDP = WHPPG * HPD
      BTUPDB = BTUPDT - BTUPDP
      WHCNA = BTUPDB * ABPDYS
C
 9990 CONTINUE
      RETURN
      END
```

APPENDIX A

PRINT SUBROUTINE LISTINGS

```
      SUBROUTINE PRNTMS(IBP)
C
C**********************************************************************
C
C  PRINTING MASTER SUBROUTINE FOR NNAUP.
C
C  R. J. RETTBERG  5 OCT 1979.
C
C**********************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     8                IMNTH1, IMNTH2
C
C--START EXECUTABLE STMTS.
C
      IF(IBP .GT. 1) GO TO 1200
C
C--PRINT APPLIANCE INPUT DATA.
C
C--   PRINT HEADER.
C
      CALL PRNTA(1)
C
C--   PRINT INPUT DATA.
C
      CALL PRNTB
C
C--PRINT LIGHTING INPUT DATA.
C
C--   PRINT HEADER.
C
      CALL PRNTA(2)
C
C--   PRINT INPUT DATA.
C
      CALL PRNTC
C
 1200 CONTINUE
C
C--PRINT FIRST SET OF OUTPUT DATA.
C
C--   PRINT HEADER.
C
      CALL PRNTA(3)
C
C--   PRINT OUTPUT DATA.
C
      CALL PRNTD(IBP)
C
      IF(IBP .LT. NBPDS) GO TO 9990
C
C--PRINT SECOND SET OF OUTPUT DATA.
C
C--   PRINT HEADER.
C
      CALL PRNTA(4)
C
C--   PRINT OUTPUT DATA.
C
      CALL PRNTE(IBP)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRNTA(IX)
C
C*****************************************************************************
C
C  HEADER FOR INPUT & OUTPUT DATA PRINTING SUBROUTINES.
C
C  R. J. RETTBERG  3 OCT 1979.
C
C*****************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'ID.COM'
      COMMON /   IDI/ INVSC, FAMNAM(8), STREET(8), IDNTS(8)
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
      INCLUDE 'STTL.COM'
      COMMON /  STTLI/ STTL(4, 3)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      GO TO (1051, 1052, 1053, 1054) IX
C
 1051 CONTINUE
      WRITE(IWRITE, 6010)
 6010    FORMAT('1', /T30, '***** APPLIANCE INPUT DATA *****', ///)
      GO TO 1060
C
 1052 CONTINUE
      WRITE(IWRITE, 6011)
 6011    FORMAT('1', /T30, '***** LIGHTING INPUT DATA *****', ///)
      GO TO 1060
C
 1053 CONTINUE
      WRITE(IWRITE, 6012)
 6012    FORMAT('1', /T30, '***** BILLING PERIOD CONSUMPTION *****',
     &       ///)
      GO TO 1060
C
 1054 CONTINUE
      WRITE(IWRITE, 6013)
 6013    FORMAT('1', /T35, '***** SUMMARY OF BILLING',
     &       ' PERIOD CONSUMPTION RESULTS *****', ///)
      GO TO 1060
C
 1060 CONTINUE
C
      WRITE(IWRITE, 6030) NRES, NLOC,
     &                     (STTL(NLOC, JA), JA = 1, 3), NOCC
 6030     FORMAT( T10, 'NRES = ', I4, T30, 'NLOC = ', I1,
     &          ' (', 3A5, ')', T90, I2, ' OCCUPANTS.', //)
C
      IF(IX .EQ. 3)WRITE(IWRITE, 6050) IDAY1, IMNTH1,
     &                                 IDAY2, IMNTH2, NBPDYS
 6050    FORMAT(T10, 'BP START:  DAY #', I3, ' (MONTH #',
     &          I2, ')', T30, 'BP END:  DAY #', I3,
     &          ' (MONTH #', I2, ')', T90,
     &          '# DAYS IN THE BILLING PERIOD = ', I3, //)
```

```
C
      WRITE(IWRITE, 6070) (FAMNAM(JA), JA = 1,8)
      IF(IX .EQ. 3) GO TO 1120
      WRITE(IWRITE, 6070) (STREET(JA), JA = 1, 8)
      WRITE(IWRITE, 6070) (IDNTS(JA), JA = 1, 8)
 6070    FORMAT(T50, 8A5)
C
 1120 CONTINUE
      IF(IMVSC .EQ. 1) WRITE(IWRITE, 6080)
      IF(IMVSC .EQ. 2) WRITE(IWRITE, 6085)
 6080    FORMAT(/T50, 'MILITARY HOUSEHOLD', //)
 6085    FORMAT(/T50, 'CIVILIAN HOUSEHOLD', //)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRNTB
C
C***************************************************************************
C
C  APPLIANCE (EXCEPT LIGHTING) INPUT DATA PRINTING SUBROUTINE.
C
C  R. J. RETTBERG  5 OCT 1979.
C
C***************************************************************************
C
      DOUBLE PRECISION DPDUMA, DPDUMB, DPDUMC, DPDUMD, DPDUME, DPDUMF
C
      INCLUDE 'CD.COM'
      COMMON /  CDIE/ ICDE, ICDLE
      COMMON /  CDIG/ ICDNG, ICDLG, ICDPLT
      COMMON /  CDOG/ CDPPG
      INCLUDE 'CW.COM'
      COMMON /  CWIE/ ICWE, ICWLE
      INCLUDE 'DW.COM'
      COMMON /  DWIE/ IDWE
      INCLUDE 'FR.COM'
      COMMON /  FRIE/ IFRE, IFRLE, FRPE
      INCLUDE 'FU.COM'
      COMMON /  FUIE/ IFUE
      COMMON /  FUIG/ IFUNG, FUBPG, IFUPLT
      COMMON /  FUOG/ IFUPOO(2), FUPPG
      INCLUDE 'RE.COM'
      COMMON /  REIE/ NRE, IRELE(3), REPE(3)
      INCLUDE 'RO.COM'
      COMMON /  SUIE/ ISUE
      COMMON /  SUIG/ ISUNG, NSUPLS, ISUPLT
      COMMON /  OVIE/ IOVE
      COMMON /  OVIG/ IOVNG, NOVPLS, IOVPLT
      COMMON /  SUOG/ SUPPG
      COMMON /  OVOG/ OVPPG
      INCLUDE 'TV.COM'
      COMMON /  TVIE/ NTV, ICVSM(3), TVPE(3)
      INCLUDE 'WH.COM'
      COMMON /  WHIE/ IWHE, IWHLE, WHCAPE
      COMMON /  WHIG/ IWHNG, IWHLG, WHCAPG, IWHPLT
      COMMON /  WHOE/ WHBPE, WHVNE
      COMMON /  WHOG/ WHBPG, WHPPG, WHVNG
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
C--DO CLOTHES DRYER.
C
      WRITE(IWRITE, 6010)
 6010    FORMAT(//T20, 'CLOTHES DRYER:')
      IF(ICDE .NE. 1 .AND. ICDNG .NE. 1) WRITE(IWRITE,6012)
 6012    FORMAT(T40, 'NO.')
      IF(ICDE .NE. 1) GO TO 1015
      DPDUMA = 'UNHEATED S'
      DPDUMB = 'ACE.      '
      IF(ICDLE .EQ. 1) DPDUMA = 'HEATED SPA'
      IF(ICDLE .EQ. 1) DPDUMB = 'CE.       '
      WRITE(IWRITE,6014) DPDUMA, DPDUMB
 6014    FORMAT(T40, 'YES:  ELECTRIC;  LOCATED IN ', 2A10)
C
 1015 CONTINUE
      IF(ICDNG .NE. 1) GO TO 1020
      DPDUMA = ' IN UNHEAT'
      DPDUMB = 'ED SPACE; '
      IF(ICDLG .EQ. 1) DPDUMA = ' IN HEATED'
      IF(ICDLG .EQ. 1) DPDUMB = ' SPACE;   '
      DPDUMC = 'STANDING  '
      IF(ICDPLT .EQ. 2) DPDUMC = 'AUTOMATIC '
      WRITE(IWRITE,6016) DPDUMA, DPDUMB, DPDUMC
 6016    FORMAT(T40, 'YES:  NATURAL GAS; LOCATED', 2A10,
     &          A10, 'PILOT.')
C
```

```
      1020 CONTINUE
     C
     C--DO CLOTHES WASHER.
     C
           WRITE(IWRITE, 6020)
      6020    FORMAT(/T20, 'CLOTHES WASHER:')
           IF(ICWE .NE. 1) WRITE(IWRITE,6022)
      6022    FORMAT(T40, 'NO.')
           IF(ICWE .NE. 1) GO TO 1030
           DPDUMA = 'UNHEATED S'
           DPDUMB = 'PACE.     '
           IF(ICWLE .EQ. 1) DPDUMA = 'HEATED SPA'
           IF(ICWLE .EQ. 1) DPDUMB = 'CE.       '
           WRITE(IWRITE,6024) DPDUMA, DPDUMB
      6024    FORMAT(T40, 'YES:  LOCATED IN ', 2A10)
     C
      1030 CONTINUE
     C
     C--DO DISHWASHER.
     C
           WRITE(IWRITE, 6030)
      6030    FORMAT(/T20, 'DISHWASHER:')
           IF(IDWE .NE. 1) WRITE(IWRITE,6032)
      6032    FORMAT(T40, 'NO.')
           IF(IDWE .NE. 1) GO TO 1040
           WRITE(IWRITE,6034)
      6034    FORMAT(T40, 'YES.')
     C
      1040 CONTINUE
     C
     C--DO FREEZER.
     C
           WRITE(IWRITE, 6040)
      6040    FORMAT(/T20, 'FREEZER:')
           IF(IFRE .NE. 1) WRITE(IWRITE,6042)
      6042    FORMAT(T40, 'NO.')
           IF(IFRE .NE. 1) GO TO 1050
           DPDUMA = 'UNHEATED S'
           DPDUMB = 'PACE.     '
           IF(IFRLE .EQ. 1) DPDUMA = 'HEATED SPA'
           IF(IFRLE .EQ. 1) DPDUMB = 'CE.       '
           WRITE(IWRITE,6044) FRPE, DPDUMA, DPDUMB
      6044    FORMAT(T40, 'YES:  ENERGY-CONSUMPTION = ', F6.1,
         &            ' KWH / MONTH:',
         &            ' LOCATED IN ', 2A10)
     C
      1050 CONTINUE
     C
     C--DO FURNACE.
     C
           WRITE(IWRITE, 6050)
      6050    FORMAT(/T20, 'FURNACE:')
           IF(IFUE .NE. 1 .AND. IFUNG .NE. 1) WRITE(IWRITE,6052)
      6052    FORMAT(T40, '?????????')
           IF(IFUE .NE. 1) GO TO 1055
           WRITE(IWRITE,6054)
      6054    FORMAT(T40, 'ELECTRIC.')
     C
      1055 CONTINUE
           IF(IFUNG .NE. 1) GO TO 1060
           DPDUMC = 'STANDING  '
           IF(IFUPLT .EQ. 2) DPDUMC = 'AUTOMATIC '
           WRITE(IWRITE,6056) FUBPG, DPDUMC
      6056    FORMAT(T40, 'NATURAL GAS WITH AN INPUT RATING OF ', F9.0,
         &            ' BTU / H WITH ', A10, 'PILOT.')
     C
      1060 CONTINUE
     C
     C--DO REFRIGERATORS.
     C
```

```
      WRITE(IWRITE, 6060)
 6060    FORMAT(/T20, 'REFRIGERATORS:')
      IF(NRE .LT. 1) WRITE(IWRITE,6062)
 6062    FORMAT(T40, '?????????')
      IF(NRE .LT. 1) GO TO 1070
C
      DO 1065 I = 1, NRE
         DPDUMA = 'UNHEATED S'
         DPDUMB = 'ACE.      '
         IF(IRELE(I) .EQ. 1) DPDUMA = 'HEATED SPA'
         IF(IRELE(I) .EQ. 1) DPDUMB = 'CE.       '
         WRITE(IWRITE,6064) I, REPE(I), DPDUMA, DPDUMB
 6064       FORMAT(T40, '# ', I1,
     &              ':  ENERGY CONSUMPTION = ', F6.1,
     &              ' KWH / MONTH:  LOCATED IN ', 2A10)
 1065 CONTINUE
C
 1070 CONTINUE
C
C--DO RANGES & OVENS.
C
      WRITE(IWRITE, 6070)
 6070    FORMAT(/T20, 'RANGES & OVENS:')
      IDUMA = 1
      IF(ISUE .NE. 1 .AND. ISUNG .NE. 1) IDUMA = 0
      IDUMB = 1
      IF(IOVE .NE. 1 .AND. IOVNG .NE. 1) IDUMB = 0
      IF(IDUMA .NE. 1 .AND. IDUMB .NE. 1) WRITE(IWRITE,6072)
 6072    FORMAT(T40, '?????????')
      IF(IDUMA .NE. 1) GO TO 1075
C
C--SURFACE UNITS.
C
      DPDUMA = ' STANDING '
      IF(ISUPLT .EQ. 2) DPDUMA = ' AUTOMATIC'
      IF(ISUE .EQ. 1) WRITE(IWRITE, 6073)
 6073    FORMAT(T40, 'SURFACE UNITS:  ELECTRIC.')
      IF(ISUE .EQ. 1) GO TO 1075
      WRITE(IWRITE,6074) NSUPLS, DPDUMA
 6074    FORMAT(T40, 'SURFACE UNITS:  NATURAL GAS: ', I1,
     &              1A10, ' PILOT LIGHTS.')
C
 1075 CONTINUE
C
C--OVENS.
C
      IF(IDUMB .NE. 1) GO TO 1080
      DPDUMA = ' STANDING '
      IF(IOVPLT .EQ. 2) DPDUMA = ' AUTOMATIC'
      IF(IOVE .EQ. 1) WRITE(IWRITE, 6075)
 6075    FORMAT(T40, 'OVENS:  ELECTRIC.')
      IF(IOVE .EQ. 1) GO TO 1080
      WRITE(IWRITE,6076) NOVPLS, DPDUMA
 6076    FORMAT(T40, 'OVENS:  NATURAL GAS:', I2,
     &              1A10, ' PILOT LIGHTS.')
C
 1080 CONTINUE
C
C--DO TELEVISIONS.
C
      WRITE(IWRITE, 6080)
 6080    FORMAT(/T20, 'TELEVISIONS:')
      IF(NTV .LT. 1) WRITE(IWRITE,6082)
 6082    FORMAT(T40, '?????????')
      IF(NTV .LT. 1) GO TO 1090
C
```

```
      DO 1085 I = 1, NTV
         DPDUMA = 'COLOR SET:'
         IF(ICVSM(I) .EQ. 2) DPDUMA = 'B & W SET:'
         WRITE(IWRITE,6084) I, DPDUMA, TYPE(I)
 6084       FORMAT(T40, '# ', I1,
     &                 ':  ', 1A10,
     &                 ' POWER = ', F6.1,
     &                 ' WATTS.')
 1085 CONTINUE
C
 1090 CONTINUE
C
C--DO WATER HEATER.
C
      WRITE(IWRITE, 6090)
 6090    FORMAT(/T20, 'WATER HEATER:')
      IF(IWHE .NE. 1 .AND. IWHNG .NE. 1) WRITE(IWRITE,6092)
 6092    FORMAT(T40, '?????????')
      IF(IWHE .NE. 1) GO TO 1095
C
C--   ELECTRIC.
C
      DPDUMA = 'UNHEATED S'
      DPDUMB = 'ACE.      '
      IF(IWHLE .EQ. 1) DPDUMA = 'HEATED SPA'
      IF(IWHLE .EQ. 1) DPDUMB = 'CE.       '
      WRITE(IWRITE,6094) WHCAPE, DPDUMA, DPDUMB
 6094    FORMAT(T40, 'ELECTRIC:  CAPACITY = ', F5.1, ' GAL;',
     &            ' LOCATED IN ', 2A10)
C
 1095 CONTINUE
C
C--   NATURAL GAS.
C
      IF(IWHNG .NE. 1) GO TO 1100
      DPDUMA = ' IN UNHEAT'
      DPDUMB = 'ED SPACE; '
      IF(IWHLG .EQ. 1) DPDUMA = ' IN HEATED'
      IF(IWHLG .EQ. 1) DPDUMB = ' SPACE;   '
      DPDUMC = 'STANDING  '
      IF(IWHPLT .EQ. 2) DPDUMC = 'AUTOMATIC '
      WRITE(IWRITE,6096) WHCAPG, DPDUMA, DPDUMB, DPDUMC
 6096    FORMAT(T40, 'NATURAL GAS:  CAPACITY =', F5.1, ' GAL;',
     &         ' LOCATED', 2A10,
     &            ' ', A10, 'PILOT.')
C
 1100 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRNTC
C
C*****************************************************************************
C
C  LIGHTING INPUT DATA PRINTING SUBROUTINE.
C
C  R. J. RETTBERG  5 OCT 1979.
C
C*****************************************************************************
C
      INCLUDE 'LI.COM'
      COMMON / LIINR/ NBAR, NBER
      COMMON / LIISF/ ALTSF, AKSF, ALRSF, BASF(3), BESF(5),
     &                DENSF, DRSF, HWSF
      COMMON / LIIEI/ ALTPEI, AKPEI, ALRPEI, BAPEI(3), BEPEI(5),
     &                DENPEI, DRPEI, HWPEI, ODPEI
      COMMON / LIIEF/ ALTPEF, AKPEF, ALRPEF, BAPEF(3), BEPEF(5),
     &                DENPEF, DRPEF, HWPEF, ODPEF
      COMMON /LIIMIS/ ODHPD
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      WRITE(IWRITE, 6010)
 6010    FORMAT(//, T60, 'SQUARE FEET',
     &           T81, 'WATTS', T101, 'WATTS',
     &           /T77, '(FLOURESCENT)', T96, '(INCANDESCENT)',
     &           /T60, '-----------', T77, '-------------',
     &           T96, '--------------', /)
C
C--DO KITCHEN.
C
      WRITE(IWRITE, 6020)
 6020    FORMAT(/T20, 'KITCHEN:')
      IF(AKSF .LT. 0.01) WRITE(IWRITE,6022)
 6022    FORMAT(T65, ' --- ', T85, ' --- ', T105, ' --- ')
      IF(AKSF .LT. 0.01) GO TO 1030
      IF(AKPEI .LT. 0.01)WRITE(IWRITE, 6024) AKSF, AKPEF
      IF(AKPEF .LT. 0.01) WRITE(IWRITE, 6026) AKSF, AKPEI
      IF(AKPEI .GT.0.01 .AND. AKPEF .GT. 0.01)
     &   WRITE(IWRITE, 6028) AKSF, AKPEF, AKPEI
 6024    FORMAT(T60, F10.1, T80, F10.1, T105, ' --- ')
 6026    FORMAT(T60, F10.1, T85, ' --- ', T100, F10.1)
 6028    FORMAT(T60, F10.1, T80, F10.1, T100, F10.1)
C
 1030 CONTINUE
C
C--DO LIVING ROOM.
C
      WRITE(IWRITE, 6030)
 6030    FORMAT(/T20, 'LIVING ROOM:')
      IF(ALRSF .LT. 0.01) WRITE(IWRITE,6022)
      IF(ALRSF .LT. 0.01) GO TO 1040
      IF(ALRPEI .LT. 0.01)WRITE(IWRITE, 6024) ALRSF, ALRPEF
      IF(ALRPEF .LT. 0.01) WRITE(IWRITE, 6026) ALRSF, ALRPEI
      IF(ALRPEI .GT.0.01 .AND. ALRPEF .GT. 0.01)
     &   WRITE(IWRITE, 6028) ALRSF, ALRPEF, ALRPEI
C
 1040 CONTINUE
C
C--DO BATHROOMS.
C
      WRITE(IWRITE, 6040)
 6040    FORMAT(/T20, 'BATHROOMS:')
C
      DO 1045 I = 1, NBAR
         IF(BASF(I) .LT. 0.01) WRITE(IWRITE,6042) I
         IF(BASF(I) .LT. 0.01) GO TO 1050
         IF(BAPEI(I) .LT. 0.01)WRITE(IWRITE, 6044) I, BASF(I),
     &      BAPEF(I)
         IF(BAPEF(I) .LT. 0.01) WRITE(IWRITE, 6046) I, BASF(I),
     &      BAPEI(I)
```

```
            IF(BAPEI(I) .GT.0.01 .AND. BAPEF(I) .GT. 0.01)
     &         WRITE(IWRITE, 6048) I, BASF(I), BAPEF(I), BAPEI(I)
 6042         FORMAT(T45, '*', I1,
     &                T65, ' --- ', T85, ' --- ', T105, ' --- ')
 6044         FORMAT(T45, '*', I1,
     &                T60, F10.1, T80, F10.1, T105, ' --- ')
 6046         FORMAT(T45, '*', I1,
     &                T60, F10.1, T85, ' --- ', T100, F10.1)
 6048         FORMAT(T45, '*', I1,
     &                T60, F10.1, T80, F10.1, T100, F10.1)
 1045   CONTINUE
C
 1050   CONTINUE
C
C--DO BEDROOMS.
C
        WRITE(IWRITE, 6050)
 6050      FORMAT(/T20, 'BEDROOMS:')
C
        DO 1055 I = 1, NBER
            IF(BESF(I) .LT. 0.01) WRITE(IWRITE.6042) I
            IF(BESF(I) .LT. 0.01) GO TO 1060
            IF(BEPEI(I) .LT. 0.01)WRITE(IWRITE, 6044) I, BESF(I),
     &         BEPEF(I)
            IF(BEPEF(I) .LT. 0.01) WRITE(IWRITE, 6046) I, BESF(I),
     &         BEPEI(I)
            IF(BEPEI(I) .GT.0.01 .AND. BEPEF(I) .GT. 0.01)
     &         WRITE(IWRITE, 6048) I, BESF(I), BEPEF(I), BEPEI(I)
 1055   CONTINUE
C
 1060   CONTINUE
C
C--DO DEN.
C
        WRITE(IWRITE, 6060)
 6060      FORMAT(/T20, 'DEN:')
        IF(DENSF .LT. 0.01) WRITE(IWRITE,6022)
        IF(DENSF .LT. 0.01) GO TO 1070
        IF(DENPEI .LT. 0.01)WRITE(IWRITE, 6024) DENSF, DENPEF
        IF(DENPEF .LT. 0.01) WRITE(IWRITE, 6026) DENSF, DENPEI
        IF(DENPEI .GT.0.01 .AND. DENPEF .GT. 0.01)
     &     WRITE(IWRITE, 6028) DENSF, DENPEF, DENPEI
C
 1070   CONTINUE
C
C--DO DINING ROOM.
C
        WRITE(IWRITE, 6070)
 6070      FORMAT(/T20, 'DINING ROOM:')
        IF(DRSF .LT. 0.01) WRITE(IWRITE.6022)
        IF(DRSF .LT. 0.01) GO TO 1080
        IF(DRPEI .LT. 0.01)WRITE(IWRITE, 6024) DRSF, DRPEF
        IF(DRPEF .LT. 0.01) WRITE(IWRITE, 6026) DRSF, DRPEI
        IF(DRPEI .GT.0.01 .AND. DRPEF .GT. 0.01)
     &     WRITE(IWRITE, 6028) DRSF, DRPEF, DRPEI
C
 1080   CONTINUE
C
C--DO HALLWAYS.
C
        WRITE(IWRITE, 6080)
 6080      FORMAT(/T20, 'HALLWAYS:')
        IF(HWSF .LT. 0.01) WRITE(IWRITE.6022)
        IF(HWSF .LT. 0.01) GO TO 1090
        IF(HWPEI .LT. 0.01)WRITE(IWRITE, 6024) HWSF, HWPEF
        IF(HWPEF .LT. 0.01) WRITE(IWRITE, 6026) HWSF, HWPEI
        IF(HWPEI .GT.0.01 .AND. HWPEF .GT. 0.01)
     &     WRITE(IWRITE, 6028) HWSF, HWPEF, HWPEI
C
 1090   CONTINUE
C
C--DO OUTDOOR LIGHTING.
C
```

```
      WRITE(IWRITE, 6090)
 6090    FORMAT(/T20, 'OUTDOOR LIGHTS:')
      IF(ODPEI + ODPEF .LT. 0.01) WRITE(IWRITE,6022)
      IF(ODPEI + ODPEF .LT. 0.01) GO TO 1100
      IF(ODPEI .LT. 0.01)WRITE(IWRITE, 6092) ODHPD, ODPEF
      IF(ODPEF .LT. 0.01) WRITE(IWRITE, 6094) ODHPD, ODPEI
      IF(ODPEI .GT.0.01 .AND. ODPEF .GT. 0.01)
     &   WRITE(IWRITE, 6096) ODHPD, ODPEF, ODPEI
 6092    FORMAT(T40, '(', F4.1, ' H / DAY)', T63, ' --- ',
     &          T80, F10.1, T105, ' --- ')
 6094    FORMAT(T40, '(', F4.1, ' H / DAY)', T63, ' --- ',
     &          T85, ' --- ', T100, F10.1)
 6096    FORMAT(T40, '(', F4.1, ' H / DAY)', T63, ' --- ',
     &          T80, F10.1, T100, F10.1)
C
 1100 CONTINUE
C
C--DO TOTALS.
C
      WRITE(IWRITE, 6110)
 6110    FORMAT(/T60, '----------', T80, '----------',
     &          T100, '----------')
      WRITE(IWRITE, 6120) ALTSF, ALTPEF, ALTPEI
 6120    FORMAT(T25, 'TOTALS', T60, F10.1, T80, F10.1, T100, F10.1)
      WRITE(IWRITE, 6130)
      WRITE(IWRITE, 6130)
 6130    FORMAT(T60, '----------', T80, '----------',
     &          T100, '----------')
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRNTD(IBP)
C
C***************************************************************************
C
C  FIRST SET (MAIN) OF OUTPUT DATA PRINTING SUBROUTINE.
C
C  R. J. RETTBERG  5 OCT 1979.
C
C***************************************************************************
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
      INCLUDE 'ACONH.COM'
      COMMON / ACONH/ CWCHA, CWCHHS, CWCHUS, DWCHA, HWCHA
      INCLUDE 'ACONN.COM'
      COMMON / ACONN/ CDCNA, CDCNHS, CDCNUS, ROCNA, SUCNA,
     &                OVCNA, WHCNA
C
      INCLUDE 'BCONE.COM'
      COMMON / BCONE/ BLCEA
      INCLUDE 'BCONH.COM'
      COMMON / BCONH/ BLCHA
      INCLUDE 'BCONN.COM'
      COMMON / BCONN/ BLCNA, BLCNHS, BLCNUS, BLCNCP,
     &                BLCNFP, BLCNSP, BLCNOP, BLCNWP
C
      INCLUDE 'FFEN.COM'
      COMMON / FFENI/ BTUPCF, BTUPGO
C
      INCLUDE 'ILOAD.COM'
      COMMON /ILOADO/ ACLOAD
C
      INCLUDE 'TCONE.COM'
      COMMON / TCONE/ TCENWH, TCEWWH
      INCLUDE 'TCONH.COM'
      COMMON / TCONH/ TCH
      INCLUDE 'TCONN.COM'
      COMMON / TCONN/ TCNNWH, TCNWWH
C
      INCLUDE 'GTOT.COM'
      COMMON /  GTOT/ GTOTE(20), GTOTN(20), GTOTH(20), BPILOD(20)
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
C--SET UP TABLE HEADING.
C
      WRITE(IWRITE, 6010)
 6010    FORMAT(/T60, 'ELECTRICITY',
     &             T80, 'NATURAL GAS',
     &             T105, 'WATER',
     &             /T63, '(KWH)', T84, '(CF)', T105, '(GAL)',
     &             /T60, '-----------',
     &             T80, '-----------',
     &             T105, '-----',/)
C
C--DO CLOTHES DRYER.
C
      WRITE(IWRITE, 6020)
 6020    FORMAT(T20, 'CLOTHES DRYER:')
      DUMA = CDCNA / BTUPCF
      IF(CDCEA .LT. 0.01 .AND. DUMA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(CDCEA .LT. 0.01 .AND. DUMA .GT. 0.01)
     &   WRITE(IWRITE, 6024) DUMA
```

```
      IF(CDCEA .GT. 0.01 .AND. DUMA .GT. 0.01)
     &   WRITE(IWRITE, 6028) CDCEA, DUMA
      IF(CDCEA .GT. 0.01 .AND. DUMA .LT. 0.01)
     &   WRITE(IWRITE, 6026) CDCEA
 6022    FORMAT(T65, ' --- ', T85, ' --- ', T105, ' --- ')
 6024    FORMAT(T65, ' --- ', T80, F10.1, T105, ' --- ')
 6026    FORMAT(T60, F10.1, T85, ' --- ', T105, ' --- ')
 6028    FORMAT(T60, F10.1, T80, F10.1, T105, ' --- ')
C
C--DO CLOTHES WASHER.
C
      WRITE(IWRITE, 6030)
 6030    FORMAT(/T20, 'CLOTHES WASHER:')
      IF(CWCEA .LT. 0.01 .AND. CWCHA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(CWCEA .GT. 0.01 .OR. CWCHA .GT. 0.01)
     &   WRITE(IWRITE, 6034) CWCEA, CWCHA
 6034    FORMAT(T60, F10.1, T85, ' --- ', T100, F10.1)
C
C--DO DISHWASHER.
C
      WRITE(IWRITE, 6040)
 6040    FORMAT(/T20, 'DISHWASHER:')
      IF(DWCEA .LT. 0.01 .AND. DWCHA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(DWCEA .GT. 0.01 .OR. DWCHA .GT. 0.01)
     &   WRITE(IWRITE, 6034) DWCEA, DWCHA
C
C--DO FREEZER.
C
      WRITE(IWRITE, 6050)
 6050    FORMAT(/T20, 'FREEZER:')
      IF(FRCEA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(FRCEA .GT. 0.01) WRITE(IWRITE, 6026) FRCEA
C
C--DO LIGHTING.
C
      WRITE(IWRITE, 6060)
 6060    FORMAT(/T20, 'LIGHTING:')
      IF(ALICEA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(ALICEA .GT. 0.01) WRITE(IWRITE, 6026) ALICEA
C
C--DO REFRIGERATORS.
C
      WRITE(IWRITE, 6070)
 6070    FORMAT(/T20, 'REFRIGERATORS:')
      IF(RECEA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(RECEA .GT. 0.01) WRITE(IWRITE, 6026) RECEA
C
C--DO RANGES & OVENS.
C
      WRITE(IWRITE, 6080)
 6080    FORMAT(/T20, 'RANGES & OVENS:')
C
C--   DO THE SURFACE UNITS.
C
      DUMA = SUCNA / BTUPCF
      IF(SUCEA .LT. 0.01 .AND. DUMA .LT. 0.01) WRITE(IWRITE, 6081)
      IF(SUCEA .LT. 0.01 .AND. DUMA .GT. 0.01)
     &   WRITE(IWRITE, 6082) DUMA
      IF(SUCEA .GT. 0.01 .AND. DUMA .LT. 0.01)
     &   WRITE(IWRITE, 6083) SUCEA
 6081    FORMAT( /T30, 'SURFACE UNITS:',
     &              T65, ' --- ', T85, ' --- ', T105, ' --- ')
 6082    FORMAT(/T30, 'SURFACE UNITS:',
     &              T65, ' --- ', T80, F10.1, T105, ' --- ')
 6083    FORMAT(/T30, 'SURFACE UNITS:',
     &              T60, F10.1, T85, ' --- ', T105, ' --- ')
C
C--   DO THE OVENS.
C
```

```
      DUMA = OVCNA / BTUPCF
      IF(OVCEA .LT. 0.01 .AND. DUMA .LT. 0.01) WRITE(IWRITE, 6084)
      IF(OVCEA .LT. 0.01 .AND. DUMA .GT. 0.01)
     &   WRITE(IWRITE, 6085) DUMA
      IF(OVCEA .GT. 0.01 .AND. DUMA .LT. 0.01)
     &   WRITE(IWRITE, 6086) OVCEA
 6084    FORMAT( T30, 'OVENS:',
     &           T65, ' --- ', T85, ' --- ', T105, ' --- ')
 6085    FORMAT( T30, 'OVENS:',
     &           T65, ' --- ', T80, F10.1, T105, ' --- ')
 6086    FORMAT( T30, 'OVENS:',
     &           T60, F10.1, T85, ' --- ', T105, ' --- ')
C
C--DO TELEVISIONS.
C
      WRITE(IWRITE, 6090)
 6090    FORMAT(/T20, 'TELEVISIONS:')
      IF(TVCEA .LT. 0.01) WRITE(IWRITE, 6022)
      IF(TVCEA .GE. 0.01) WRITE(IWRITE, 6026) TVCEA
C
C--DO TOTALS BEFORE BASELOAD.
C
      WRITE(IWRITE, 6100)
 6100    FORMAT(/T60, '----------', T80, '----------',
     &           T100, '----------')
      DUMA = TCENWH - BLCEA
      DUMB = TCNNWH - BLCNA
      DUMB = DUMB / BTUPCF
      DUMC = TCH - BLCHA - HWCHA
      WRITE(IWRITE, 6101) DUMA, DUMB, DUMC
 6101    FORMAT (T30, 'TOTALS BEFORE BASELOAD:',
     &       T60, F10.1, T80, F10.1, T100, F10.1)
      WRITE(IWRITE, 6102)
 6102    FORMAT(T60, '----------', T80, '----------',
     &           T100, '----------')
C
C--DO BASELOAD.
C
      DUMA = BLCNA / BTUPCF
      IF(DUMA .LT. 0.01) WRITE(IWRITE, 6110) BLCEA, BLCHA
      IF(DUMA .GT. 0.01) WRITE(IWRITE, 6111) BLCEA, DUMA, BLCHA
 6110    FORMAT(/T20, 'BASELOAD:',
     &           T60, F10.1, T85, ' --- ', T100, F10.1)
 6111    FORMAT(/T20, 'BASELOAD:',
     &           T60, F10.1, T80, F10.1, T100, F10.1)
C
C--PRINT OUT DISWASHING WATER SEPARATELY IF APPROPRIATE.
C
      IF(HWCHA .LT. 0.01) GO TO 1120
      WRITE(IWRITE, 6112) HWCHA
 6112    FORMAT(T20, 'HOT WATER FOR MANUAL DISHWASHING:',
     &           T65, ' --- ', T85, ' --- ', T100, F10.1)
C
 1120 CONTINUE
C
C--DO TOTALS BEFORE WATER HEATER.
C
      WRITE(IWRITE, 6100)
      DUMA = TCNNWH / BTUPCF
      WRITE(IWRITE, 6121) TCENWH, DUMA, TCH
 6121    FORMAT (T30, 'TOTALS BEFORE WATER HEATER:',
     &       T60, F10.1, T80, F10.1, T100, F10.1)
      WRITE(IWRITE, 6102)
C
C--DO WATER HEATER.
C
```

```
      DUMA = WHCNA / BTUPCF
      IF(WHCEA .LT. 0.01 .AND. DUMA .LT. 0.01) WRITE(IWRITE, 6130)
      IF(WHCEA .LT. 0.01 .AND. DUMA .GT. 0.01)
     &   WRITE(IWRITE, 6131) DUMA
      IF(WHCEA .GT. 0.01 .AND. DUMA .LT. 0.01)
     &   WRITE(IWRITE, 6132) WHCEA
 6130    FORMAT(/T20, 'WATER HEATER:',
     &              T65, ' --- ', T85, ' --- ', T105, ' --- ')
 6131    FORMAT(/T20, 'WATER HEATER:',
     &              T65, ' --- ', T80, F10.1, T105, ' --- ')
 6132    FORMAT(/T20, 'WATER HEATER:',
     &              T60, F10.1, T85, ' --- ', T105, ' --- ')
C
C--DO **** GRAND TOTALS *****.
C
      WRITE(IWRITE, 6140)
 6140    FORMAT(/T60, '----------', T80, '----------',
     &              T100, '----------')
      DUMA = TCNWWH / BTUPCF
      WRITE(IWRITE, 6141) TCEWWH, DUMA, TCH
 6141    FORMAT (T30, '***** GRAND TOTALS ***** :',
     &         T60, F10.1, T80, F10.1, T100, F10.1)
      WRITE(IWRITE, 6102)
      WRITE(IWRITE, 6102)
C
C--SAVE THE GRAND TOTALS.
C
      GTOTE(IBP) = TCEWWH
      GTOTN(IBP) = DUMA
      GTOTH(IBP) = TCH
C
C--DO THE INTERNAL LOAD.
C
      WRITE(IWRITE, 6200) ACLOAD
 6200    FORMAT(/T50, 'THE AVERAGE INTERNAL LOAD DURING',
     &              ' THE BP:', F10.0, ' BTU / HOUR.')
C
C--SAVE THE INTERNAL LOAD.
C
      BPILOD(IBP) = ACLOAD
C
 1700 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRNTE(IBP)
C
C*****************************************************************************
C
C  SUMMARY OUTPUT DATA.
C
C  R. J. RETTBERG  15 OCT 1979
C
C*****************************************************************************
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'GTOT.COM'
      COMMON /  GTOT/ GTOTE(20), GTOTN(20), GTOTH(20), BPILOD(20)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
C--SET UP TABLE HEADING.
C
      WRITE(IWRITE, 6010)
 6010    FORMAT(/T16, 'IDAY1', T26, 'IDAY2',
     &            T40, 'ELECTRICITY', T60, 'NATURAL GAS',
     &            T86, 'WATER', T98, 'INTERNAL LOAD',
     &            /T44, '(KWH)', T65, '(CF)',
     &            T86, '(GAL)', T100, '(BTU/H)',
     &            /T16, '-----', T26, '-----',
     &            T40, '----------- ', T60, '-----------',
     &            T86, '-----', T98, '-------------', /)
C
      DO 1100 I = 1, IBP
         WRITE(IWRITE, 6020) IDAY1M(I), IDAY2M(I), GTOTE(I),
     &                       GTOTN(I), GTOTH(I), BPILOD(I)
 6020       FORMAT(/, I20, I10, 3(F20.1), F20.0)
 1100 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

APPENDIX A

MISCELLANEOUS SUBROUTINE LISTINGS

```
      SUBROUTINE APMSFA
C
C*****************************************************************************
C
C  APPLIANCE MONTHLY CONSUMPTION VARIATION AVERAGING.
C
C  R. J. RETTBERG  20 SEPT 1979.
C
C*****************************************************************************
C
      NAMELIST /APSFAD/ CDMSFA, CWMSFA, DWMSFA, FRMSFA, REMSFA,
     &                  ROMSFA, SUMSFA, OVMSFA, TVMSFA, WHMSFA
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &               IMNTH1, IMNTH2
C
      INCLUDE 'CAL.COM'
      COMMON /  CALI/ IDTOM(365)
C
      INCLUDE 'CDMSF.COM'
      COMMON /CDMSFS/ CDMSFA, CDMSF(12)
      INCLUDE 'CWMSF.COM'
      COMMON /CWMSFS/ CWMSFA, CWMSF(12)
      INCLUDE 'DWMSF.COM'
      COMMON /DWMSFS/ DWMSFA, DWMSF(12)
      INCLUDE 'FRMSF.COM'
      COMMON /FRMSFS/ FRMSFA, FRMSF(12)
      INCLUDE 'REMSF.COM'
      COMMON /REMSFS/ REMSFA, REMSF(12)
      INCLUDE 'ROMSF.COM'
      COMMON /ROMSFS/ ROMSFA, ROMSF(12)
      COMMON /SUMSFS/ SUMSFA, SUMSF(12)
      COMMON /OVMSFS/ OVMSFA, OVMSF(12)
      INCLUDE 'TVMSF.COM'
      COMMON /TVMSFS/ TVMSFA, TVMSF(12)
      INCLUDE 'WHMSF.COM'
      COMMON /WHMSFS/ WHMSFA, WHMSF(12)
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      DO 1050 I = 1, 10
         DDUMA(I) = 0.
 1050 CONTINUE
C
      DO 1060 I = IDAY1, IDAY2
         IX = IDTOM(I)
         DDUMA(1) = DDUMA(1) + CDMSF(IX)
         DDUMA(2) = DDUMA(2) + CWMSF(IX)
         DDUMA(3) = DDUMA(3) + DWMSF(IX)
         DDUMA(4) = DDUMA(4) + FRMSF(IX)
         DDUMA(5) = DDUMA(5) + REMSF(IX)
         DDUMA(6) = DDUMA(6) + ROMSF(IX)
         DDUMA(7) = DDUMA(7) + SUMSF(IX)
         DDUMA(8) = DDUMA(8) + OVMSF(IX)
         DDUMA(9) = DDUMA(9) + TVMSF(IX)
         DDUMA(10) = DDUMA(10) + WHMSF(IX)
 1060 CONTINUE
C
```

```
      ABPDYS = 1. / FLOAT(NBPDYS)
      CDMSFA = DDUMA(1) * ABPDYS
      CWMSFA = DDUMA(2) * ABPDYS
      DWMSFA = DDUMA(3) * ABPDYS
      FRMSFA = DDUMA(4) * ABPDYS
      REMSFA = DDUMA(5) * ABPDYS
      ROMSFA = DDUMA(6) * ABPDYS
      SUMSFA = DDUMA(7) * ABPDYS
      OVMSFA = DDUMA(8) * ABPDYS
      TVMSFA = DDUMA(9) * ABPDYS
      WHMSFA = DDUMA(10) * ABPDYS
C
      IF(IPRNT(22) .NE. 1) GO TO 9990
      WRITE(IWRITE, APSFAD)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ILMS
C
C************************************************************************
C
C  INTERNAL LOAD CALCULATION MASTER SUBROUTINE.
C
C  R. J. RETTBERG   24 SEPT 1979.
C
C************************************************************************
C
      NAMELIST / ILMSD/ BLCEA,
     &                  CDCEA, CDCEHS, CDCEUS,
     &                  CWCEA, CWCEHS, CWCEUS,
     &                  DWCEA,
     &                  FRCEA, FRCEHS, FRCEUS,
     &                  ALICEA, ALICEO, ALICEH,
     &                  RECEA, RECEHS, RECEUS,
     &                  ROCEA, SUCEA, OVCEA,
     &                  TVCEA,
     &                  WHCEA, WHCEHS, WHCEUS, WHCEI,
     &                  CDCNA, CDCNHS, CDCNUS,
     &                  ROCNA, SUCNA, OVCNA,
     &                  WHCNA,
     &                  BLCHA,
     &                  CWCHA, CWCHHS, CWCHUS,
     &                  DWCHA, HWCHA,
     &                  TCH
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
C
      INCLUDE 'ACONE.COM'
      COMMON / ACONE/ CDCEA, CDCEHS, CDCEUS, CWCEA, CWCEHS, CWCEUS,
     &                DWCEA, FRCEA, FRCEHS, FRCEUS,
     &                ALICEA, ALICEO, ALICEH,
     &                RECEA, RECEHS, RECEUS,
     &                ROCEA, SUCEA, OVCEA, TVCEA,
     &                WHCEA, WHCEHS, WHCEUS, WHCEI
      INCLUDE 'ACONH.COM'
      COMMON / ACONH/ CWCHA, CWCHHS, CWCHUS, DWCHA, HWCHA
      INCLUDE 'ACONN.COM'
      COMMON / ACONN/ CDCNA, CDCNHS, CDCNUS, ROCNA, SUCNA,
     &                OVCNA, WHCNA
C
      INCLUDE 'BCONE.COM'
      COMMON / BCONE/ BLCEA
      INCLUDE 'BCONH.COM'
      COMMON / BCONH/ BLCHA
      INCLUDE 'BCONN.COM'
      COMMON / BCONN/ BLCNA, BLCNHS, BLCNUS, BLCNCP,
     &                BLCNFP, BLCNSP, BLCNOP, BLCNWP
C
      INCLUDE 'TCONH.COM'
      COMMON / TCONH/ TCH
C
      INCLUDE 'ILOAD.COM'
      COMMON /ILOADO/ ACLOAD
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      ACLOAD = BLCEA + CDCEHS + CWCEHS + DWCEA + FRCEHS + ALICEH +
     &         RECEHS + ROCEA + TVCEA + WHCEHS
      ACLOAD = 3413. * ACLOAD
```

```
C
C--ADD 30 % OF THE BTU IN THE HOT WATER EXCLUDING CLOTHES WASHER
C--    HOT WATER IF CW IN UNHEATED SPACE ASSUMING AN 35 DEG-F
C--    RISE IN WATER TEMPERATURE & STORED ENERGY OF 8.331 BTU / GAL
C--    / DEG-F.
C
      ACLOAD = ACLOAD + 0.30 * (TCH - CWCHUS) * 8.331 * 35.0
      ACLOAD = ACLOAD + CDCNHS + ROCNA + BLCNHS
C
C--CONVERT TO BTU / HOUR FROM BTU FOR THE BILLING PERIOD
C--    & ADD IN PEOPLE LOAD @ 500 BTU / HOUR EACH
C--    BUT W/ A 50% PRESENCE/ACTIVITY FACTOR.
C
      ACLOAD = ACLOAD / (24. * FLOAT(NBPDYS))
      ACLOAD = ACLOAD + 0.5 * (500. * FLOAT(NOCC))
C
      IF(IPRNT(45) .NE. 1) GO TO 1900
      WRITE(IWRITE, ILMSD)
C
 1900 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INIMS
C
C*****************************************************************************
C
C  INITIALIZATION MASTER SUBROUTINE.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*****************************************************************************
C
      INCLUDE 'CAL.COM'
      COMMON /  CALI/ IDTOM(365)
      INCLUDE 'FFEN.COM'
      COMMON / FFENI/ BTUPCF, BTUPGO
      INCLUDE 'STTL.COM'
      COMMON /  STTLI/ STTL(4, 3)
      INCLUDE 'SUN.COM'
      COMMON /  SUNI/ SRTIM(4, 12), SSTIM(4, 12)
      COMMON /  SUNO/ SRTIMA, SSTIMA
      INCLUDE 'TIDB.COM'
      COMMON / TIDBI/ TIDBM(12)
      COMMON / TIDBO/ TIBSAV, TIUSAV
C
C--INITIALIZE /  CALI/ .
C
      DATA IDTOM/ 31*1, 28*2, 31*3, 30*4, 31*5,
     &            30*6, 31*7, 31*8, 30*9, 31*10,
     &            30*11, 31*12/
C
C--INITIALIZE / FFENI/
C
      DATA  BTUPCF/ 1021./
      DATA  BTUPGO/ 130000./
C
C--INITIALIZE / STTLI/ .
C
      DATA (STTL(1, JA), JA = 1,3) / 'FORT ', 'EUSTI', 'S    '/
      DATA (STTL(2, JA), JA = 1,3) / 'GREAT', ' LAKE', 'S    '/
      DATA (STTL(3, JA), JA = 1,3) / 'FORT ', 'HOOD ', '     '/
      DATA (STTL(4, JA), JA = 1,3) / 'POINT', ' MUGU', '     '/
C
C--INITIALIZE /  SUNI/ .
C
      DATA (SRTIM(1,JA),JA=1,12)/ 5.00, 5.00, 5.00, 5.00, 5.00,
     &                            5.00, 5.00, 6.25, 6.50, 5.00,
     &                            5.00, 5.00/
      DATA (SSTIM(1,JA),JA=1,12)/ 20.00, 20.00, 20.00, 20.00, 20.00,
     &                            20.00, 20.00, 20.00, 19.00, 20.00,
     &                            20.00, 20.00/
      DATA (SRTIM(2,JA),JA=1,12)/ 5.00, 5.00, 5.00, 5.00, 5.00,
     &                            5.00, 5.467, 5.967, 6.50, 5.00,
     &                            5.00, 5.00/
      DATA (SSTIM(2,JA),JA=1,12)/ 20.00, 20.00, 20.00, 20.00, 20.00,
     &                            20.00, 20.00, 19.867, 19.00, 20.00,
     &                            20.00, 20.00/
      DATA (SRTIM(3,JA),JA=1,12)/ 5.00, 5.00, 5.00, 5.00, 5.00,
     &                            5.00, 5.50, 6.00, 5.00, 5.00,
     &                            5.00, 5.00/
      DATA (SSTIM(3,JA),JA=1,12)/ 20.00, 20.00, 20.00, 20.00, 20.00,
     &                            20.00, 19.30, 19.26, 20.00, 20.00,
     &                            20.00, 20.00/
      DATA (SRTIM(4,JA),JA=1,12)/ 5.00, 5.00, 5.00, 5.00, 5.00,
     &                            5.00, 5.933, 6.283, 6.65, 5.00,
     &                            5.00, 5.00/
      DATA (SSTIM(4,JA),JA=1,12)/ 20.00, 20.00, 20.00, 20.00, 20.00,
     &                            20.00, 20.133, 19.717, 19.05, 20.00,
     &                            20.00, 20.00/
```

```
C
C--INITIALIZE / TIDBI/ .
C
      DATA TIDBM / 70., 70., 72., 74., 76., 78.,
     3              80., 80., 78., 76., 74., 72./
C
C--START EXECUTABLE STATEMENTS.
C
      CALL INIMSF
      CALL RWR
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INIMSF
C
C*****************************************************************************
C
C  INITIALIZATION OF MONTHLY SCALE FACTORS FOR APPLIANCE ENERGY
C  CONSUMPTION.
C
C  R. J. RETTBERG   20 SEPT 1979.
C
C*****************************************************************************
C
C  REFERENCES:
C
C     1. "COLOR TELEVISION ENERGY USE STUDY."  P G & E.
C        WALTER BLUMST.  OCT 1972 - JAN 1974.
C
C*****************************************************************************
C
      INCLUDE 'CDMSF.COM'
      COMMON /CDMSFS/ CDMSFA, CDMSF(12)
      INCLUDE 'CWMSF.COM'
      COMMON /CWMSFS/ CWMSFA, CWMSF(12)
      INCLUDE 'DWMSF.COM'
      COMMON /DWMSFS/ DWMSFA, DWMSF(12)
      INCLUDE 'FRMSF.COM'
      COMMON /FRMSFS/ FRMSFA, FRMSF(12)
      INCLUDE 'REMSF.COM'
      COMMON /REMSFS/ REMSFA, REMSF(12)
      INCLUDE 'ROMSF.COM'
      COMMON /ROMSFS/ ROMSFA, ROMSF(12)
      COMMON /SUMSFS/ SUMSFA, SUMSF(12)
      COMMON /OVMSFS/ OVMSFA, OVMSF(12)
      INCLUDE 'TVMSF.COM'
      COMMON /TVMSFS/ TVMSFA, TVMSF(12)
      INCLUDE 'WHMSF.COM'
      COMMON /WHMSFS/ WHMSFA, WHMSF(12)
C
      DATA CDMSF/ 1.080, 1.080, 1.040, 1.010, 0.970, 0.950,
     &            0.840, 0.950, 0.960, 1.000, 1.020, 1.070/
C
      DATA CWMSF/ 1.000, 1.000, 1.040, 1.040, 1.040, 0.960,
     &            0.870, 1.000, 1.040, 1.080, 1.000, 1.000/
C
      DATA DWMSF/ 1.020, 1.100, 1.070, 1.120, 1.020, 0.950,
     &            0.380, 0.830, 0.900, 0.950, 0.970, 1.050/
C
      DATA FRMSF/ 0.880, 0.900, 0.920, 0.990, 1.030, 1.050,
     &            1.040, 1.120, 1.120, 1.050, 0.980, 0.900/
C
      DATA REMSF/ 0.900, 0.910, 0.980, 1.040, 1.040, 1.070,
     &            1.090, 1.050, 1.050, 1.000, 0.943, 0.910/
C
      DATA ROMSF/ 1.240, 1.200, 1.050, 0.940, 0.870, 0.310,
     &            0.820, 0.860, 0.910, 1.030, 1.110, 1.180/
      DATA SUMSF/ 1.160, 1.160, 0.970, 0.890, 1.240, 0.710,
     &            0.690, 0.910, 0.960, 1.070, 1.130, 1.080/
      DATA OVMSF/ 1.220, 1.080, 1.000, 0.980, 0.880, 0.349,
     &            0.730, 0.750, 0.920, 1.170, 1.170, 1.200/
C
C--TV MONTHLY SCALE FACTORS FROM REF. 1 BASED ON DAILY AVERAGE
C--    VIEWING HOURS.
C
      DATA TVMSF/ 6.400, 6.170, 5.860, 5.310, 5.270, 4.920,
     &            4.950, 5.270, 5.760, 5.990, 6.360, 6.110/
C
      DATA WHMSF/ 1.100, 1.120, 1.100, 1.030, 0.940, 0.850,
     &            0.850, 1.050, 0.940, 0.950, 1.000, 1.040/
C
C--START EXECUTABLE STATEMENTS.
C
```

```
C--HALVE THE WHMSF VARIATION FROM 1.00 ON THE THEORY THAT HALF
C--   THE VARIATION IS DUE TO DEL-TEMP (ACCOUNTED FOR BY OTHER
C--   MEANS ELSEWHERE) & HALF TO USAGE VARIATONS.
C
      DO 1100 I = 1, 12
         DEL = WHMSF(I) - 1.00
         DEL = DEL * 0.5
         WHMSF(I) = 1.00 + DEL
 1100 CONTINUE
C
C--ADJUST TV MONTHLY SCALE FACTORS SO ANNUAL AVERAGE IS 1.
C
      DO 1120 I = 1, 12
         TVMSF(I) = TVMSF(I) / 3.75
 1120 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SRSSA
C
C*****************************************************************************
C
C  SUNRISE & SUNSET TIME AVERAGEING OVER BILLING PERIOD DAYS.
C
C  R. J. RETTBERG   25 SEPT 1979.
C
C*****************************************************************************
C
      NAMELIST /SRSSAD/ SRTIMA, SSTIMA
C
      INCLUDE 'CASE.COM'
      COMMON / CASEI/ NBPDS, IDAY1M(20), IDAY2M(20)
      COMMON / CASEO/ NLOC, NRES, IDAY1, IDAY2, NBPDYS,
     &                IMNTH1, IMNTH2
C
      INCLUDE 'CAL.COM'
      COMMON /  CALI/ IDTOM(365)
      INCLUDE 'SUN.COM'
      COMMON /  SUNI/ SRTIM(4, 12), SSTIM(4, 12)
      COMMON /  SUNO/ SRTIMA, SSTIMA
C
      INCLUDE 'DDUMX.COM'
      COMMON / DDUMX/ DDUMA(20), DDUMB(20), DDUMC(20), DDUMD(20)
C
      INCLUDE 'RW.COM'
      COMMON /    RW/ ITTY, IREAD, IWRITE, IPRNT(75)
C
C--START EXECUTABLE STMTS.
C
      DO 1050 I = 1, 2
         DDUMA(I) = 0.
 1050 CONTINUE
C
      DO 1100 I = IDAY1, IDAY2
         IX = IDTOM(I)
         DDUMA(1) = DDUMA(1) + SRTIM(NLOC, IX)
         DDUMA(2) = DDUMA(2) + SSTIM(NLOC, IX)
 1100 CONTINUE
C
      SRTIMA = DDUMA(1) / FLOAT(NBPDYS)
      SSTIMA = DDUMA(2) / FLOAT(NBPDYS)
      IF(IPRNT(23) .NE. 1) GO TO 9990
      WRITE(IWRITE, SRSSAD)
C
 9990 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ZERO
C
C**********************************************************************
C
C  INITIALIZATION OF VARIABLES FOR NNAUP.
C
C  R. J. RETTBERG   24 SEPT 1979.
C
C**********************************************************************
C
      INCLUDE 'CD.COM'
      COMMON /  CDIE/ ICDE, ICDLE
      COMMON /  CDIG/ ICDNG, ICDLG, ICDPLT
      COMMON /  CDOG/ CDPPG
      INCLUDE 'CW.COM'
      COMMON /  CWIE/ ICWE, ICWLE
      INCLUDE 'DW.COM'
      COMMON /  DWIE/ IDWE
      INCLUDE 'FR.COM'
      COMMON /  FRIE/ IFRE, IFRLE, FRPE
      INCLUDE 'FU.COM'
      COMMON /  FUIE/ IFUE
      COMMON /  FUIG/ IFUNG, FUBPG, IFUPLT
      COMMON /  FUOG/ IFUPOO(2), FUPPG
      INCLUDE 'ID.COM'
      COMMON /   IDI/ IMVSC, FAMNAM(8), STREET(8), IDNTS(8)
      INCLUDE 'LI.COM'
      COMMON / LIINR/ NBAR, NBER
      COMMON / LIISF/ ALTSF, AKSF, ALRSF, BASF(3), BESF(3),
     &                DENSF, DRSF, HWSF
      COMMON / LIIEI/ ALTPEI, AKPEI, ALRPEI, BAPEI(3), BEPEI(3),
     &                DENPEI, DRPEI, HWPEI, ODPEI
      COMMON / LIIEF/ ALTPEF, AKPEF, ALRPEF, BAPEF(3), BEPEF(3),
     &                DENPEF, DRPEF, HWPEF, ODPEF
      COMMON /LIIMIS/ ODHPD
      INCLUDE 'OC.COM'
      COMMON /   OCI/ NOCC
      INCLUDE 'RO.COM'
      COMMON /  SUIE/ ISUE
      COMMON /  SUIG/ ISUNG, NSUPLS, ISUPLT
      COMMON /  OVIE/ IOVE
      COMMON /  OVIG/ IOVNG, NOVPLS, IOVPLT
      COMMON /  SUOG/ SUPPG
      COMMON /  OVOG/ OVPPG
      INCLUDE 'WH.COM'
      COMMON /  WHIE/ IWHE, IWHLE, WHCAPE
      COMMON /  WHIG/ IWHNG, IWHLG, WHCAPG, IWHPLT
      COMMON /  WHOE/ WHBPE, WHVNE
      COMMON /  WHOG/ WHBPG, WHPPG, WHVNG
C
C--START EXECUTABLE STMTS.
C
      ICDE = 0
      ICDNG = 0
      ICWE = 0
      IDWE = 0
      IFRE = 0
      IFUE = 0
      IFUNG = 0
      IMVSC = ' '
C
      ALTSF = 0.
      AKSF = 0.
      ALRSF = 0.
      DENSF = 0.
      DRSF = 0.
      HWSF = 0.
C
      ALTPEI = 0.
      AKPEI = 0.
      ALRPEI = 0.
      DENPEI = 0.
      DRPEI = 0.
      HWPEI = 0.
      ODPEI = 0.
C
```

```
      ALTPEF = 0.
      AKPEF = 0.
      ALRPEF = 0.
      DENPEF = 0.
      DRPEF = 0.
      HWPEF = 0.
      ODPEF = 0.
C
      ODHPD = 0.
C
      ISUE = 0
      ISUNG = 0
      IOVE = 0
      IOVNG = 0
      IWHE = 0
      IWHNG = 0
C
C--PICK UP THE PILOTS EVEN THOUGH NOT REALLY NECESSARY.
C
      CDPPG = 0.
      FUPPG = 0.
      SUPPG = 0.
      OVPPG = 0.
      WHPPG = 0.
C
      DO 1130 I = 1, 3
         BASF(I) = 0.
         BAPEI(I) = 0.
         BAPEF(I) = 0.
 1130 CONTINUE
C
      DO 1150 I = 1, 5
         BESF(I) = 0.
         BEPEI(I) = 0.
         BEPEF(I) = 0.
 1150 CONTINUE
C
      DO 1180 I = 1, 8
         FAMNAM(I) = '        '
         STREET(I) = '        '
         IDNTS(I) = '        '
 1180 CONTINUE
C
 9990 CONTINUE
      RETURN
      END
```

APPENDIX B

NORM SPACE HEATING AND COOLING PROGRAM COMPUTER LISTING

(MODIFIED HEAP)

```
      PROGRAM SABLE
C     ******   SCIENCE APPLICATIONS BUILDING LOADS ESTIMATE (SABLE)   *****
C     THIS IS THE MAIN PROGRAM
      DIMENSION B(100),BB(40)
      COMMON/LOOP/NL1,NL2,LUW
      INTEGER BLDGFL,WTHRFL
      WRITE(5,1000)
 1000 FORMAT(' ENTER BUILDING DATA FILE NAME - ')
      READ (5,900) BLDGFL
      IF(BLDGFL.EQ.5H     ) BLDGFL = 5HBLDGF
      WRITE(5,1001)
 1001 FORMAT(' ENTER WEATHER DATA FILE NAME - ')
       READ (5,900) WTHRFL
      IF(WTHRFL.EQ.5H     ) WTHRFL = 5HWTHRF
  900 FORMAT(A5)
      WRITE(5,2000)
 2000 FORMAT(' ENTER PRINT DISPOSITION:  1=TERMINAL, 2=LINE PRINTER - ')
      READ(5,901) LUW
  901 FORMAT(I1)
      IF(LUW.NE.2)LUW=5
      IF(LUW.EQ.2) LUW=3
      WRITE(LUW,2500) BLDGFL, WTHRFL
 2500 FORMAT(1H1,20X,'BUILDING FILE = ',A5,'(.DAT)     WEATHER FILE = ',
     +      A5,'(.DAT)')
      OPEN(UNIT=20,FILE=BLDGFL)
      OPEN(UNIT=21,FILE=WTHRFL)
      READ(20,999) (B(I),I=1,95)
   10 READ(21,999,END=16) (BB(I),I=1,40)
  999 FORMAT (7F10.0,10X)
      NL1 = 1
      NL2 = 2
      IF(BB(27) .LE. 0.0) NL1 = 2
      IF(BB(28) .LE. 0.0) NL2 = 1
      IF (BB(27) .LE. 0.0 .AND. BB(28) .LE. 0.0) WRITE(LUW,15)
   15 FORMAT(' HREQ = 0)'//' CREQ = 0')
      CALL HCLD(B,BB)
      GO TO 10
   16 CLOSE(UNIT=20,FILE=BLDGFL)
      CLOSE(UNIT=21,FILE=WTHRFL)
   12 END
      SUBROUTINE PRNTIN(B,BB)
      DIMENSION B(100), BB(40)   ,R(10)
      DIMENSION N(35)
      COMMON/DATA/BLOUT(4,12)
      COMMON/LOOP/NL1,NL2,LUW
      DATA N/5HWALL ,2H1 ,2H2 ,2H3 ,2H4 ,5HNET W,5HWINDO,4HW    ,
     A 5HDOOR ,4H    ,4H1.13,4H0.50,5HSURFA,5HCE AB,5HSORPT,5HIVITY,
     B 5HSHADI,5HNG   ,5H     ,4H0.40,4H0.55,4HALL ,5HBASEM,4HENT ,
     A 5HCRAWL,5H SPAC,2HE ,5HSLAB ,5HON GR,4HADE ,5HFEET ,5HBTU/H,
     B 5HR-FT ,1H2,5HATTIC/
      IF(B(92).LE.1.) GO TO 700
      WRITE(LUW,1050)
      WRITE(LUW,1060)
      WRITE(LUW,1040)
      WRITE(LUW,1070) (B(I),I,I=4,5)
      WRITE(LUW,1080) B(1), B(2)
      J=92
      WRITE(LUW,1090) (B(I),I,I=62,67),(B(I),I,I=93,95),B(J),J
      WRITE(LUW,1130)
      WRITE(LUW,1060)
      WRITE(LUW,1110) B(69),B(49),B(44),B(48),B(51),B(52),B(47),
     +      B(50),B(54),B(45),B(46)
      WRITE(LUW,1140)
      WRITE(LUW,1150)
      WRITE(LUW,1060)
      WRITE(LUW,1160) B(43),B(42),B(41),B(72),B(61)
```

```
      WRITE(LUW,1170) B(53),B(58),B(70) ,B(59)
      WRITE(LUW,1180) B(73),B(74)
      WRITE(LUW,1240) B(75),B(71),B(55)
      WRITE(LUW,1190) (N(25),N(26),N(27),I=1,2),B(57),
     A  (N(25),N(26),N(27),I=1,2),N(31),B(60),
     B  (N(28),N(29),N(30),I=1,2),N(31),B(56)
      WRITE(LUW,1200) B(68)
      WRITE(LUW,1250)
      WRITE(LUW,1060)
      IA=3
      WRITE(LUW,1254) N(1),N(2),B(3),IA
      DO 607 I=2,4
      IA=5*I
      IC=I+1
      WRITE(LUW,1257) N(1),N(IC),B(IA),IA
  607 CONTINUE
      IA=28
      WRITE(LUW,1260) N(6),N(22),N(1),N(2),B(IA),IA
      DO 608 I=2,4
      IA=I*4 + 24
      IC=I+1
      WRITE(LUW,1265) N(1),N(IC),B(IA),IA
  608 CONTINUE
      IA=27
      WRITE(LUW,1270) N(1),N(2),B(IA),IA
      DO 619 I=2,4
      IA=4*I + 23
      IC=I+1
      WRITE(LUW,1275) N(1),N(IC),B(IA),IA
  619 CONTINUE
      IA=25
      WRITE(LUW,1280) N(1),N(2),B(IA),IA
      DO 618 I=2,4
      IA=21 + 4*I
      IC=I+1
      WRITE(LUW,1285) N(1),N(IC),B(IA),IA
  618 CONTINUE
      IA=26
      WRITE(LUW,1290) N(13),N(14),N(15),N(16),N(1),N(2),B(IA),IA
      DO 617 I=2,4
      IA= 22 + 4*I
      IC=I+1
      WRITE(LUW,1295) N(1),N(IC), B(IA),IA
  617 CONTINUE
      IA=6
      WRITE(LUW,1260) N(7),N(8),N(1),N(2),B(IA),IA
      DO 610 I=2,4
      IA= I*5 + 1
      IC=I+1
      WRITE(LUW,1265) N(1),N(IC),B(IA),IA
  610 CONTINUE
      IA=8
      WRITE(LUW,1270) N(1),N(2),B(IA),IA
      DO 616 I=2,4
      IA=I*5+3
      IC=I+1
      WRITE(LUW,1275) N(1),N(IC),B(IA),IA
  616 CONTINUE
      IA=9
      WRITE(LUW,1280) N(1),N(2),B(IA),IA
      DO 615 I=2,4
      IA=4+5*I
      IC=I+1
      WRITE(LUW,1285) N(1),N(IC),B(IA),IA
  615 CONTINUE
      IA=7
```

```
      WRITE(LUW,1290) N(17),N(18),N(19),N(19),N(1),N(2),B(IA),IA
      DO 614 I=2,4
      IA=5*I+2
      IC=I+1
      WRITE(LUW,1295) N(1),N(IC),B(IA),IA
  614 CONTINUE
      IA=79
      WRITE(LUW,1260) N(9),N(10),N(1),N(2),B(IA),IA
      DO 611 I=2,4
      IA= 4*I + 75
      IC=I+1
      WRITE(LUW,1265) N(1),N(IC),B(IA),IA
  611 CONTINUE
      IA=78
      WRITE(LUW,1270) N(1),N(2),B(IA),IA
      DO 613 I=2,4
      IA= I*4 + 74
      IC=I+1
      WRITE(LUW,1275) N(1),N(IC),B(IA),IA
  613 CONTINUE
      IA=76
      WRITE(LUW,1280) N(1),N(2),B(IA),IA
      DO 612 I=2,4
      IA= 72 + 4*I
      IC=I+1
      WRITE(LUW,1285) N(1),N(IC), B(IA),IA
  612 CONTINUE
      IA=77
      WRITE(LUW,1290) N(13),N(14),N(15),N(16),N(1),N(2),B(IA),IA
      DO 609 I=2,4
      IA= I*4 + 73
      IC=I+1
      WRITE(LUW,1295) N(1),N(IC),B(IA),IA
  609 CONTINUE
      WRITE(LUW,1300)
      WRITE (LUW,2003)
      WRITE (LUW,1061)
      WRITE(LUW,2200) BB(9),BB(10),(I,I=9,10),BB(11),BB(12),(I,I=11,12)
      WRITE(LUW,2004)
      WRITE(LUW,2220) BB(17),BB(18),(I,I=17,18),BB(31),BB(32),
     +        (I,I=31,32),
     +          BB(29),BB(30),(I,I=29,30), BB(15),BB(16), (I,I=15,16),
     +          BB(33),BB(34),(I,I=33,34)
      WRITE (LUW,2004)
      WRITE(LUW,2240) BB(13),BB(14),(I,I=13,14)
      WRITE(LUW,2004)
      WRITE(LUW,2260) BB(1),BB(2), (I,I=1,2), BB(3),BB(4),(I,I=3,4),
     +          BB(37),BB(38),(I,I=37,38),BB(39),BB(40),(I,I=39,40)
      WRITE(LUW,2004)
      WRITE(LUW,2280) BB(5),BB(6),(I,I=5,6), BB(7),BB(8),(I,I=7,8)
      WRITE(LUW,2004)
      WRITE(LUW,2300)BB(25),BB(26),(I,I=25,26),BB(23),BB(24),(I,I=23,24)
      WRITE(LUW,2004)
      WRITE(LUW,2320)BB(19),BB(20),(I,I=19,20),BB(21),BB(22),(I,I=21,22)
      WRITE(LUW,2004)
      WRITE(LUW,2340) BB(35), BB(36), (I, I = 35, 36)
      WRITE(LUW,2004)
      WRITE(LUW,2360) (BB(I),I,I=27,28)
      WRITE(LUW,2004)
      WRITE(LUW,2005)
 1300 FORMAT(1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     A  15(1H-),'|')
      RETURN
  700 WRITE(LUW,89)
      WRITE(LUW,90) (I,B(I),I=1,95)
      WRITE(LUW,91)
```

```
      WRITE(LUW,90) (I,BB(I),I=1,40)
   89 FORMAT(/1H1,'B ARRAY')
   90 FORMAT (10(I4,F9.3))
   91 FORMAT(//' BB ARRAY')
 1050 FORMAT(/1H ,54X,'GENERAL DATA'/)
 1060 FORMAT(1H0,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     +       15(1H-),'|'/1H ,'|',70X,'|',15X,'|',10X,'|',15X,'|'/
     +       1H ,'|',30X,'VARIABLES',31X,'|',5X,'UNITS',5X,
     +       '|    VALUE    |   LOCATION IN   |'/1H ,'|',70X,'|',15X,
     +       '|',10X,'|       B ARRAY     |'/1H ,'|',70X,'|',
     +       15X,'|',10X,'|',15X,'|'/1H ,'|',70(1H-),'|',15(1H-),
     +       '|',10(1H-),'|',15(1H-),'|')
 1040 FORMAT(1H ,'|',3X,'LOCATION-SPECIFIC DATA:',44X,'|',15X,'|',
     +       10X,'|',15X,'|')
 1070 FORMAT(1H ,'|',8X,'LATITUDE',54X,'| DEGREES NORTH |',
     +       F9.3,' |',6X,I3,6X,'|'/1H ,'|',8X,'GROUND SURFACE ',
     +       'REFLECTANCE',36X,'|',15X,'|',F9.3,' |',6X,I3,6X,
     +       '|')
 1080 FORMAT(1H ,'|',3X,
     +       'BUILDING DESIGN DATA:',46X,'|',15X,'|',10X,'|',15X,
     +       '|'/1H ,'|',8X,'VOLUME OF HEATED LIVING AREA',34X,'|',
     +       3X,'CUBIC FEET',2X,'|',F9.3,' |',8X,'1',6X,'|'
     +       /1H ,'|',8X,
     +       'STANDARD AIR LEAKAGE DATA',37X,'| AIRCHANGES/HR |',
     +       F9.3,' |',8X,'2',6X,'|')
 1090 FORMAT(1H ,'|',8X,'OCCUPANCY  DAYTIME',44X,'|',4X,'PERSONS',
     +       4X,'|',F9.3,' |',6X,I3,6X,'|'/1H ,'|',19X,
     +       'NIGHTTIME',42X,'|',4X,'PERSONS',4X,'|',F9.3,
     +       ' |',6X,I3,6X,'|'/1H ,'|',8X,'AVERAGE LIGHTING  DAYTIME',
     +       37X,'|',5X,'WATTS',5X,'|',F9.3,' |',6X,I3,6X,'|'/
     +       1H ,'|',26X,'NIGHTTIME',35X,'|',5X,'WATTS',5X,
     +       '|',F9.3,' |',6X,I3,6X,'|'/1H ,'|',8X,'AVERAGE ELECTRICAL ',
     +       'EQUIVALENT FOR GAS APPLIANCE  DAYTIME',6X,'|',5X,'WATTS',
     +       5X,'|',F9.3,' |',6X,I3,6X,'|'/1H ,'|',57X,
     +       'NIGHTTIM',
     +       'E',4X,'|',5X,'WATTS',5X,'|',F9.3,' |',6X,I3,6X,'|'/
     +       1H ,'|',8X,'CAC RATED ENERGY EFFICIENCY RATIO',29X,
     +       '|  BTU/WATT-HR  |',F9.3,' |',6X,I3,6X,'|'/
     +       1H ,'|',8X,'FURNACE FLAG',50X,'|',15X,'|',F9.3,' |',
     +       6X,I3,6X,'|'/
     +       1H ,'|',8X,'FURNACE EFFICIENCY',44X,'|     PERCENT    |',
     +       F9.3,' |',6X,I3,6X,'|'/
     +          1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     +       15(1H-),'|'/1H ,'|',3X,'DEBUG PARAMETER:',51X,'|',15X,'|',
     +       10X,'|',15X,'|'/1H ,'|',8X,'DEBUG',57X,'|',15X,'|',
     +       F9.3,' |',6X,I3,6X,'|'/1H ,'|',70(1H-),'|',15(1H-),
     +       '|',10(1H-),'|',15(1H-),'|')
 1130 FORMAT(1H1,47X,'ATTIC AND ROOF HEAT LOSS DATA'/)
 1170 FORMAT(1H ,'|',3X,'U VALUE FOR FLOOR OF FIRST STORY',3X,
     +       'BASEMENT',24X,'|',3X,'BTU/HR-FT2',2X,'|',
     +       F9.3,' |',7X,'53',6X,'|'/1H ,'|',3X,35X,'CRAWL SPACE',
     +       21X,'|',3X,'BTU/HR-FT2',2X,'|',F9.3,' |',
     +       7X,'58',6X,'|'/1H ,'|',3X,'WALL U VALUE',3X,
     +       'BASEMENT',44X,'|',3X,'BTU/HR-FT2',2X,'|',
     +       F9.3,' |',7X,'70',6X,'|'/1H ,'|',18X,'CRAWL SPACE',41X,
     +       '|',3X,'BTU/HR-FT2',2X,'|',F9.3,' |',
     +       7X,'59',6X,'|'/1H ,'|',70(1H-),'|',15(1H-),'|',
     +       10(1H-),'|',15(1H-),'|')
 1160 FORMAT(1H ,'|',3X,'FRACTION OF FLOOR AREA',3X,'BASEMENT',34X,
     +       '|',15X,'|',F9.3,' |',7X,'43',6X,'|'/1H ,'|',28X,
     +       'CRAWL SPACE',31X,'|',15X,'|',F9.3,' |',7X,'42',
     +       6X,'|'/1H ,'|',28X,'SLAB ON GRADE',29X,'|',15X,'|',
     +       F9.3,' |',7X,'41',6X,'|'/1H ,'|',70(1H-),'|',15(1H-),
     +       '|',10(1H-),'|',15(1H-),'|'/1H ,'|',3X,
     +       'WALL AREA (IN CONTACT WITH GROUND)',3X,'BASEMENT',22X,'|',
     +       2X,'SQUARE FEET',2X,'|',F9.3,' |',7X,'72',6X,'|'/
```

```
     +       1H ,'|',
     +         40X,'CRAWL SPACE',19X,'|',2X,'SQUARE FEET',2X,'|',
     +       F9.3,' |',7X,'61',6X,'|')
1140 FORMAT(                           1H ,'|',70(1H-),'1',15(1H-),'|',
     +       10(1H-),'|',15(1H-),'|')
1110 FORMAT(                                        1H ,'|',3X,'AREA ',
     +       'OF ATTIC FLOOR',48X,'|  SQUARE FEET  |',
     +       F9.3,' |',7X,'69',6X,'|'/1H ,'|',3X,'ATTIC END WALL AREA',
     +       48X,'|  SQUARE FEET  |',F9.3,' |',7X,'49',6X,'|'/
     +       1H ,'|',3X,'NON-ATTIC ROOF AREA',48X,'|  SQUARE FEET  |',
     +       F9.3,' |',7X,'44',6X,'|'/1H ,'|',3X,'ATTIC ',
     +       'END WALL HEIGHT',46X,'|',6X,'FEET',5X,'|',
     +       F9.3,' |',7X,'48',6X,'|'/1H ,'|',3X,'CEILING U VALUE',
     +       52X,'|',3X,'BTU/HR-FT2',2X,'|',F9.3,' |',6X,
     +       ' 51',6X,'|'/1H ,'|',3X,'ATTIC END WALL U VALUE',45X,'|',
     +       3X,'BTU/HR-FT2',2X,'|',F9.3,' |',6X,
     +       ' 52',6X,'|'/1H ,'|',3X,'ROOF U VALUE',55X,'|',3X,'BTU/HR-',
     +       'FT2',2X,'|',F9.3,' |',6X,' 47',6X,'|'/1H ,
     +       '|',3X,'ATTIC AIR CHANGES PER HOUR',41X,'| AIRCHANGES/HR |',
     +       F9.3,' |',6X,' 50',6X,'|'/1H ,'|',3X,'ATTIC ',
     +       'TEMPERATURE CONTROL',42X,'|',15X,'|',F9.3,' |',6X,
     +       ' 54',6X,'|'/1H ,'|',3X,'ROOF SHADOW FACTOR',49X,'|',15X,
     +       '|',F9.3,' |',6X,' 45',6X,'|'/1H ,'|',3X,
     +       'ROOF ABSORPTIVITY',50X,'|',15X,'|',F9.3,
     +       ' |',6X,' 46',6X,'|')
1150 FORMAT(1H0//,1H ,52X,'FLOOR HEAT LOSS DATA'/)
1200 FORMAT(1H ,'|',3X,'TOTAL FLOOR AREA',51X,'|',2X,'SQUARE FEET',2X,
     +       '|',F9.3,' |',6X,' 68',6X,'|'/
     +       1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     +       15(1H-),'|')
1190 FORMAT(
     +       1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     +       15(1H-),'|'/
     +       1H ,'|',3X,2A5,A2,'AIR CHANGES PER HOUR',3X,2A5,A2,
     +       20X,'|',1X,'AIRCHANGES/HR',1X,'|',F9.3,' |',
     +       6X,' 57',6X,'|'/
     +       1H ,'|',3X,2A5,A2,'HEIGHT',3X,2A5,A2,34X,'|',6X,
     +       A5,4X,'|',F9.3,' |',6X,' 60',6X,'|'/
     +       1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     +       15(1H-),'|'/
     +       1H ,'|',3X,'EXPOSED PERIMETER LENGTH OF ',2A5,A4,2X,2A5,A4,
     +       9X,'|',6X,A5,4X,'|',F9.3,' |',
     +       6X,' 56',6X,'|'/
     +       1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',
     +       15(1H-),'|')
1240 FORMAT(1H ,'|',3X,'BASEMENT HEAT GAIN FROM FURNACE AND OTHER ',
     +       'EQUIPMENT',3X,'BASEMENT',5X,'|',5X,'BTU/HR',4X,'|',
     +       F9.3,' |',6X,' 75',6X,'|'/
     +       1H ,'|',3X,'GROUND AROUND WALLS U VALUE',3X,'BASEMENT',29X,
     +       '|',3X,'BTU/HR-FT2',2X,'|',
     +       F9.3,' |',6X,' 71',6X,'|'/
     +       1H ,'|',3X,'BASEMENT TEMPERATURE CONTROL INDEX',3X,
     +       'BASEMENT',22X,'|',15X,'|',F9.3,' |',6X,' 55',6X,'|'
     +       )
1180 FORMAT(1H ,'|',3X,'BASEMENT FLOOR U VALUE',3X,'BASEMENT',34X,
     +       '|',3X,'BTU/HR-FT2',2X,'|',F9.3,' |',6X,
     +       ' 73',6X,'|'/
     +       1H ,'|',3X,'GROUND UNDER FLOOR U VALUE',3X,'BASEMENT',
     +       30X,'|',3X,'BTU/HR-FT2',2X,'|',F9.3,' |',
     +       6X,' 74',6X,'|')
1250 FORMAT(1H1,53X,'WALL HEAT LOSS DATA'/)
1280 FORMAT(1H ,'|',14X,'SHADOW',3X,A5,A2,40X,'|',15X,'|',
    AF9.3,' |',6X,I3,6X,'|')
1285 FORMAT(1H ,'|',23X,A5,A2,40X,'|',15X,'|',
    AF9.3,' |',6X,I3,6X,'|')
1290 FORMAT(1H ,'|',14X,4A5,3X,A5,A2,26X,'|',15X,'|',F9.3,
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      A' |',6X,I3,6X,'|')
 1295 FORMAT(1H ,'|',37X,A5,A2,26X,'|',15X,'|',
      AF9.3,' |',6X,I3,6X,'|')
 1270 FORMAT(1H ,'|',14X,'U VALUE',3X,A5,A2,39X,'|',3X,'BTU/HR-FT2',2X,
      A'|',F9.3,' |',6X,I3,6X,'|')
 1275 FORMAT(1H ,'|',24X,A5,A2,39X,
      A'|',3X,'BTU/HR-FT2',2X,'|',F9.3,' |',6X,I3,6X,'|')
 1260 FORMAT(1H ,'|',70(1H-),'|',15(1H-),'|',10(1H-),'|',15(1H-),
      A  '|'/1H ,'|',3X,A5,A4,3X,'AREA',3X,A5,A2,41X,'|',2X,
      B  'SQUARE FEET',2X,'|',F9.3,' |',6X,I3,6X,'|')
 1265 FORMAT(1H ,'|',22X,A5,A2,41X,'|',2X,
      A'SQUARE FEET',2X,'|',F9.3,' |',6X,I3,6X,'|')
 1254 FORMAT(1H ,'|',3X,'ORIENTATION FROM SOUTH',3X,A5,A2,33X,'|',4X,
      A'DEGREES',4X,'|',F9.3,' |',6X,I3,6X,'|')
 1257 FORMAT(1H ,'|',28X,A5,A2,
      B35X,'|',4X,'DEGREES',4X,'|',F9.3,' |',6X,I3,6X,'|')
 2003 FORMAT(1H1,42X,'WEATHER / SEASONAL DEPENDENT DATA')
 1061 FORMAT(1H0,'|',60(1H-),'|',15(1H-),'|',10(1H-),'|',
     +        10(1H-),'|',15(1H-),'|'/1H ,'|',60X,'|',15X,'|',
     +        10X,'|',10X,'|',15X,'|'/
     +        1H ,'|',25X,'VARIABLES',26X,'|',5X,'UNITS',5X,
     +        '| VALUE #1 | VALUE #2 |  LOCATION IN  |'/
     +        1H ,'|',60X,'|',15X,'|',2(4X,'*',5X,'|'),
     +        '    BB ARRAY    |'/
     +        1H ,'|',60X,'|',15X,'|',10X,'|',10X,'|',15X,'|'/
     +        1H ,'|',60(1H-),'|',15(1H-),'|',10(1H-),'|',
     +        10(1H-),'|',15(1H-),'|')
 2200 FORMAT(1H ,'|',3X,'WIND SPEED    DAYTIME',37X,'|',
     +        6X,'MPH',6X,'|',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',16X,'NIGHTTIME',35X,'|',6X,'MPH',6X,'|',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|')
 2004 FORMAT(1H ,'|',60(1H-),'|',15(1H-),'|',10(1H-),
     +        '|',10(1H-),'|',15(1H-),'|')
 2220 FORMAT(1H ,'|',3X,'SOLAR/ATMOSPHERIC DATA',
     +        35X,'|',15X,'|',10X,'|',10X,'|',15X,'|'/
     +        1H ,'|',9X,'HORIZONTAL SOLAR INSOLATION',24X,
     +        '|  BTU/DAY/FT2  |',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',9X,'RATIO OF SOLAR RADIATION INTENSITY TO GAMMA',
     +        8X,'|',15X,'|',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',9X,'DECLINATION',40X,'|    DEGREES    |',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',9X,'LIU/JORDAN FACTOR',34X,'|',15X,'|',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',9X,'ATMOSPHERIC EXTINCTION COEFFICIENT',
     +        17X,'|',15X,'|',2(F9.3,' |'),I6,' -',I3,4X,'|')
 2240 FORMAT(1H ,'|',3X,'GROUND TEMPERATURE',39X,'|   DEGREES F   |',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|')
 2260 FORMAT(1H ,'|',3X,'OUTDOOR TEMPERATURE    DAYTIME',28X,
     +        '|   DEGREES F   |',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',25X,'NIGHTTIME',26X,'|   DEGREES F   |',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',25X,'AVERAGE MAXIMUM',20X,'|   DEGREES F   |',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',25X,'AVERAGE MINIMUM',20X,'|   DEGREES F   |',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|')
 2280 FORMAT(1H ,'|',3X,'INDOOR TEMPERATURE    DAYTIME',28X,
     +        '|   DEGREES F   |',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',25X,'NIGHTTIME',26X,'|   DEGREES F   |',
     +        2(F9.3,' |'),I6,' -',I3,4X,'|')
 2300 FORMAT(1H ,'|',3X,'OUTDOOR RELATIVE HUMIDITY    DAYTIME',22X,
     +        '|    PERCENT    |',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',31X,'NIGHTTIME',20X,'|    PERCENT    |',2(F9.3,' |'),
     +        I6,' -',I3,4X,'|')
 2320 FORMAT(1H ,'|',3X,'INDOOR RELATIVE HUMIDITY    DAYTIME',22X,
     +        '|    PERCENT    |',2(F9.3,' |'),I6,' -',I3,4X,'|'/
     +        1H ,'|',31X,'NIGHTTIME',20X,'|    PERCENT    |',
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     +       2(F9.3,' |'),I6,' -',I3,4X,'|')
C
C--CHANGED !!!!!!!
C
 2340 FORMAT(1H ,'|',3X,'SURFACE HEAT TRANSFER COEFFICIENT',24X,'|',
     +       5X,'BTU/',6X,'|',F9.3,' |',F9.3,' |',I6, ' -',I3,4X,'|'/
     +       1H ,'|',60X,'|  HR-FT2-DEG F |',10X,'|',10X,
     &       '|',15X,'|')
C
 2360 FORMAT(1H ,'|',3X,'NUMBER OF DAYS     HEATING',32X,'|',15X,'|',
     +       F9.3,' |',10X,'|',6X,I3,6X,'|'/
     +       1H ,'|',21X,'COOLING',32X,'|',15X,'|',F9.3,' |',10X,'|',
     +       6X,I3,6X,'|')
 2005 FORMAT(///1H '* FOR ALL TWO ELEMENT ARRAYS VALUE #1',
     +       ' (FIRST ELEMENT IN THE ARRAY) IS THE VALUE FOR HEATING',
     +       ' DAYS'/1H ,2X,'VALUE #2 IS FOR COOLING DAYS')
      RETURN
      END
      SUBROUTINE QG (AG, SC, UG, TOD, TON, TID, TIN, SHDW, XIDT, XIDD,
     1              QCD, QCN, SCD)
C     THIS IS WINDOW HEAT GAIN ROUTINE @ QG@
C
C     *** INPUT ***
C
C         AG      @ GLASS AREA
C         SC      @ SHADING COEFFICIENT
C         UG      @ HEAT TRANSFER COEFFICIENT
C         TOD     @ DAYTIME OUTDOOR TEMPERATURE
C         TON     @ NIGHTTIME OUTDOOR TEMPERATURE
C         TID     @ DAYTIME INDOOR TEMPERATURE
C         TIN     @ NIGHTTIME INDOOR TEMPERATURE
C         SHDW    @ EXTERNAL SHADOW FACTOR
C                   0.0 = NO SHADOW
C                   0.5 = PARTIAL SHADOW
C                   1.0 = COMPLETE SHADOW
C         XIDT    @ DAILY TOTAL RADIATION
C         XIDD    @ DAILY DIFFUSE RADIATION
C
C     *** OUTPUT ***
C
C         QCD     @ DAYTIME WINDOW HEAT GAIN
C         QCN     @ NIGHTTIME WINDOW HEAT GAIN
C
      DIMENSION TOD(2), TON(2), TID(2), TIN(2), XIDT(2), XIDD(2),
     1          QCD(2), QCN(2), SCD(2)
      COMMON/LOOP/NL1,NL2,LUW
      REAL I
      DO 10 J = NL1,NL2
      I = (XIDT(J) - XIDD(J)) * (1.0 - SHDW) + XIDD(J)
      SCD(J) = AG * I *SC
      QCD(J) = AG * (I * SC + UG * (TOD(J) - TID(J)) * 12.0)
      QCN(J) = AG * (UG * (TON(J) - TIN(J)) * 12.0)
   10 CONTINUE
      RETURN
      END
      SUBROUTINE INFIL (V, ACHS, TOD, TON, TID, TIN, WSD,WSN,RINFLD,
     1                  RINFLN)
C     THIS IS INFILTRATION CALCULATION ' INFIL '
C
C     *** INPUT ***
C
C         V       = VOLUME OF THE ROOM
C         ACHS    = STANDARD AIR CHANGE DATA
C         TOD     = DAYTIME OUTDOOR TEMPERATURE
C         TON     = NIGHTTIME OUTDOOR TEMPERATURE
C         TID     = DAYTIME INDOOR TEMPERATURE
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C         TIN     = NIGHTTIME INDOOR TEMPERATURE
C         WSD      = WIND SPEED DAYTIME
C         WSN      = WIND SPEED NIGHTTIME
C
C     *** OUTPUT ***
C
C         RINFLD = INFILTRATION RATE DAY
C         RINFLN = INFILTRATION RATE NIGHT
C
      DIMENSION TOD(2), TON(2), TID(2), TIN(2), RINFLD(2), RINFLN(2)
      DIMENSION WSD(2),WSN(2)
      COMMON/LOOP/NL1,NL2,LUW
C
      DO 10 I=NL1,NL2
      ACD = ACHS/0.695*(0.15+0.013*WSD(I)+0.005*ABS(TOD(I)-TID(I)))
      ACN = ACHS/0.695*(0.15+0.013*WSN(I)+0.005*ABS(TON(I)-TIN(I)))
      RINFLD(I) = V * ACD / 60.0
      RINFLN(I) = V * ACN / 60.0
   10 CONTINUE
      RETURN
      END
      SUBROUTINE QI (INFILD,INFILN,TOD, TON,TID,TIN, RH, QID, QIN, QILD,
     1              QILN, RHM, RHA)
C
C     THIS IS INFILTRATION HEAT GAIN CALCULATION " QI "
C
C     *** INPUT ***
C
C         INFILD = INFILTRATION RATE DAYTIME CFM
C         INFILN = INFILTRATION RATE NIGHTTIME CFM
C         TOD    = DAYTIME OUTDOOR TEMPERATURE
C         TON    = NIGHTTIME OUTDOOR TEMPERATURE
C         TID    = DAYTIME INDOOR TEMPERATURE
C         TIN    = NIGHTTIME INDOOR TEMPERATURE
C         RH     = ROOM RELATIVE HUMIDITY
C         RHM    = MORNING OUTDOOR RELATIVE HUMIDITY
C         RHA     = AFTERNOON OUTDOOR RELATIVE HUMIDITY
C
C     *** OUTPUT ***
C
C         QID    = DAYTIME SENSIBLE HEAT GAIN
C         QIN    = NIGHTTIME SENSIBLE HEAT GAIN
C         QILD   = DAYTIME LATENT HEAT GAIN
C         QILN   = NIGHTTIME LATENT HEAT GAIN
C
      DIMENSION TOD(2), TON(2),  TID(2), TIN(2), RH(2,2),
     1          QID(2), QIN(2), QILD(2), QILN(2), WID(2), WIN(2),
     2          WOD(2), WON(2),RHM(2),RHA(2)
      COMMON/LOOP/NL1,NL2,LUW
      REAL INFILD(2),INFILN(2)
      DO 10 I=NL1,NL2
      QID(I) = 1.08 * INFILD(I)* (TOD(I) - TID(I)) * 12.0
      QIN(I) = 1.08 * INFILN(I)* (TON(I) - TIN(I)) * 12.0
   10 CONTINUE
C
      DO 20 I = NL1,NL2
      CALL DBRH (TID(I), RH(1, I), WID(I))
      CALL DBRH (TIN(I), RH(2, I), WIN(I))
      CALL DBRH (TOD(I),RHA(I),WOD(I))
      CALL DBRH (TON(I),RHM(I),WON(I))
      QILD(I) = 4.5 * INFILD(I)* (WOD(I) - WID(I)) * 1061.0 * 12.0
      QILN(I) = 4.5 * INFILN(I)* (WON(I) - WIN(I)) * 1061.0 * 12.0
   20 CONTINUE
      RETURN
      END
      SUBROUTINE CRAWL(TOD,TON,TC,TAD,TAN,TWMD,TWMN,CFM,UF,UW,UC,AF,AW,
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```
     *CRAWLD,CRAWLN)
C     THIS IS CRAWL SPACE TEMPERATURE ROUTINE 'CRAWL'
C
C     *** INPUT ***
C         TWMD    @ DAYTIME WALL SOL-AIR TEMPERATURE
C         TOD     @ DAYTIME OUTDOOR TEMPERATURE
C         TON     @ NIGHTTIME OUTDOOR TEMPERATURE
C         TG      @ GROUND TEMPERATURE
C         TAD     @ DAYTIME ROOM TEMPERATURE
C         TAN     @ NIGHTTIME ROOM TEMPERATURE
C         CFM     @ AIR FLOW RATE
C         UF      @ FLOOR HEAT TRANSFER COEFFICIENT
C         UW      @ WALL HEAT TRANSFER COEFFICIENT
C         UG      @ GROUND SURFACE HEAT TRANSFER COEFFICIENT = 1.0
C         AF      @ FLOOR AREA
C         AW      @ WALL AREA
C         TWMN    @ NIGHTTIME WALL SOL-AIR TEMPERATURE
C     *** OUTPUT ***
C         CRAWLD @ DAYTIME CRAWL SPACE TEMPERATURE
C         CRAWLN @ NIGHTTIME CRAWL SPACE TEMPERATURE
      DIMENSION TOD(2),TON(2),TG(2),TAD(2),TAN(2),TWMD(2),TWMN(2)
     *         ,CRAWLD(2),CRAWLN(2)
      COMMON/LOOP/NL1,NL2,LUW
C
      DO 10 I=NL1,NL2
      CRAWLD(I)=(UF*TAD(I)*AF+UW*TWMD(I)*AW+UG*(TG(I)+TAD(I))/2.0*AF+
     *1.08*CFM*TOD(I))/(UF*AF+UW*AW+UG*AF+1.08*CFM)
      CRAWLN(I)=(UF*TAN(I)*AF+UW*TWMN(I)*AW+UG*(TG(I)+TAN(I))/2.0*AF+
     *1.08*CFM*TON(I))/(UF*AF+UW*AW+UG*AF+1.08*CFM)
   10 CONTINUE
      RETURN
      END
      SUBROUTINE ATTIC(AR,TRD,TRN,AC,TAD,TAN,AW,TWD,TWN,CFM,UR,UC,UW,TOD
     *,TON,ATD,ATN)
C     THIS IS ATTIC TEMPERATURE CALCULATION 'ATTIC'
C
C     *** INPUT ***
C
C         AR      @ ROOF AREA
C         TRD     @ DAYTIME SOL-AIR TEMPERATURE
C         TRN     @ NIGHTTIME SOL-AIR TEMPERATURE
C         AC      @ CEILING AREA
C         TAD     @ DAYTIME ROOM TEMPERATURE
C         TAN     @ NIGHTTIME ROOM TEMPERATURE
C         AW      @ END WALL AREA
C         TWD     @ DAYTIME END WALL SOL-AIR TEMPERATURE
C         TWN     @ NIGHTTIME END WALL SOL-AIR TEMPERATURE
C         CFM     @ AIR FLOW
C         UR      @ U-VALUE FOR ROOF
C         UC      @ U-VALUE FOR CEILING
C         UW      @ U-VALUE FOR WALLS
C         TOD     @ DAYTIME OUTDOOR TEMPERATURE
C         TON     @ NIGHTTIME OUTDOOR TEMPERATURE
C
C     *** OUTPUT ***
C
C         ATD     @ DAYTIME ATTIC TEMPERATURE
C         ATN     @ NIGHTTIME ATTIC TEMPERATURE
      DIMENSION TRD(2),TRN(2),TOD(2),TON(2),ATD(2),
     *          ATN(2),TWD(2),TWN(2),TAD(2),TAN(2)
      COMMON/LOOP/NL1,NL2,LUW
      DO 10 I=NL1,NL2
      ATD(I)=(UR*AR*TRD(I)+UW*AW*TWD(I)+UC*AC*TAD(I)+1.08*CFM*TOD(I))/
     /(UR*AR+UW*AW+UC*AC+1.08*CFM)
      ATN(I)=(UR*AR*TRN(I)+UW*AW*TWN(I)+UC*AC*TAN(I)+1.08*CFM*TON(I))/
     /(UR*AR+UW*AW+UC*AC+1.08*CFM)
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```
   10 CONTINUE
      RETURN
      END
      SUBROUTINE HCRT (HL, HG, LHG,  HREQ, CREQ)
C
C     THIS IS HEATING AND COOLING REQUIREMENT ' HCRT '
C
C     *** INPUT ***
C
C         HL      = SENSIBLE HEAT LOSS
C         HG      = SENSIBLE HEAT GAIN
C         LHG     = LATENT HEAT GAIN
C
C
C     *** OUTPUT ***
C
C         HREQ    = HEATING REQUIREMENT
C         CREQ    = COOLING REQUIREMENT
C
      DIMENSION HL(2), HG(2), LHG(2),  HREQ(2), CREQ(2)
      COMMON/LOOP/NL1,NL2,LUW
      REAL LHG
      DO 10 I=NL1,NL2
      HREQ(I) = HL(I)
      CREQ(I) = (HG(I) + LHG(I))
   10 CONTINUE
      RETURN
      END
      SUBROUTINE GF (AF, P, TG, TOD, TON, U, TAD, TAN, GFD, GFN)
C
C     THIS IS GROUND FLOOR HEAT TRANSFER ROUTINE ' GF '
C
C     *** INPUT ***
C
C         TOD     = DAYTIME OUTDOOR TEMPERATURE
C         TON     = NIGHTTIME OUTDOOR TEMPERATURE
C         TG      = GROUND TEMPERATURE
C         AF      = FLOOR AREA
C         P       = EXPOSED PERIMETER LENGTH
C         U       = FLOOR HEAT TRANSFER COEFFICIENT
C         TAD     = DAYTIME ROOM TEMPERATURE
C         TAN     = NIGHTTIME ROOM TEMPERATURE
C     *** OUTPUT ***
C
C         GFD     = DAYTIME GROUND FLOOR HEAT TRANSFER
C         GFN     = NIGHTTIME GROUND FLOOR HEAT TRANSFER
      DIMENSION TG(2),TOD(2),TON(2),TAD(2),TAN(2),GFD(2),GFN(2)
      COMMON/LOOP/NL1,NL2,LUW
      DO 10 I=NL1,NL2
C
      XX=-0.5*TOD(I)+33.75
      IF(TOD(I).GE.60.0) XX=0.0
      YY=-0.5*TON(I)+33.75
      IF(TON(I).GE.60.0) YY=0.0
      GFD(I)=(U*AF*((TG(I)+(TAD(I)+TAN(I))/2.0)/2.0-TAD(I))-XX*P)*12.0
      GFN(I)=(U*AF*((TG(I)+(TAD(I)+TAN(I))/2.0)/2.0-TAN(I))-YY*P)*12.0
C
   10 CONTINUE
      RETURN
      END
      SUBROUTINE QR(RNPD,RNPN,WTD,WTN,WED,WEN,QRSD,QRSN,QRLD,QRLN)
C
C     THIS IS INTERNAL HEAT GAIN
C
C     *** INPUT ***
C
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C         NPD     = NUMBER OF DAYTIME OCCUPANTS
C         NPN     = NUMBER OF NIGHTTIME OCCUPANTS
C         WTD     = AVERAGE DAYTIME LIGHTING POWER W
C         WTN     = AVERAGE NIGHTTIME LIGHTING POWER W
C         WED     = AVERAGE DAYTIME EQUIPMENT POWER W
C         WEN     = AVERAGE NIGHTTIME EQUIPMENT POWER W
C
C     *** OUTPUT ***
C
C         QRSD    = DAYTIME SENSIBLE HEAT GAIN
C         QRSN    = NIGHTTIME SENSIBLE HEAT GAIN
C         QRLD    = DAYTIME LATENT HEAT GAIN
C         QRLN    = NIGHTTIME LATENT HEAT GAIN
C
      COMMON/LOOP/NL1,NL2,LUW
      QRSD=(RNPD*240.0+(WTD+(WED*0.66))*3.413)*12.0
      QRSN=(RNPN*240.0+(WTN+(WEN*0.66))*3.413)*12.0
C
      QRLD=(RNPD*160.0+WED*0.34*3.413)*12.0
      QRLN=(RNPN*160.0+WEN*0.34*3.413)*12.0
      RETURN
      END
      SUBROUTINE SAT(XIDT,XIDD,SHDW,AB,FO,WTLT,TOD,TON,SATD,SATN)
C
C     THIS IS SOL-AIR TEMPERATURE ROUTINE "SAT"
C
C     *** INPUT ***
C
C         WTLT    = TILT ANGLE
C         XIDT    = DAILY TOTAL RADIATION
C         XIDD    = DAILY DIFFUSE RADIATION
C         SHDW    = SHADOW FACTOR
C         AB      = SURFACE ABSORPTIVITY
C         FO      = SURFACE HEAT TRANSFER COEFFICIENT
C         TOD     = DAYTIME TEMPERATURE
C         TON     = NIGHTTIME TEMPERATURE
C
C     *** OUTPUT ***
C
C         SATD    = DAYTIME SOL-AIR TEMPERATURE
C         SATN    = NIGHTTIME SOL-AIR TEMPERATURE
C
      DIMENSION XIDT(2),XIDD(2),TOD(2),TON(2),SATD(2),
     1 SATN(2), FO(2)
      COMMON/LOOP/NL1,NL2,LUW
C
      XWTLT=WTLT/180.0*3.14159
      DO 10 J=NL1,NL2
      R=(XIDT(J)-XIDD(J))*(1.0-SHDW)+XIDD(J)
      SATD(J)=TOD(J)+AB*R/12.0/FO(J)-10.0/FO(J)*COS(XWTLT)
      SATN(J)=TON(J)-10.0/FO(J)*COS(XWTLT)
   10 CONTINUE
      RETURN
      END
      SUBROUTINE QECHG (SATD, SATN, U, A, TID, TIN, GD,GN)
C
C     THIS IS OPAQUE ENVELOPE CONDUCTION HEAT GAIN CALCULATIONS "QECHG"
C
C     *** INPUT ***
C
C         SATD    = DAYTIME SOL-AIR (OR ATTIC OR CRAWL SPACE) TEMPERATURE
C         SATN    = NIGHTTIME SOL-AIR(OR ATTIC OR CRAWL SPACE)TEMPERATURE
C         U       = OVERALL HEAT TRANSFER COEFFICIENT
C         A       = AREA
C         TID     = DAYTIME INDOOR TEMPERATURE
C         TIN     = NIGHTTIME INDOOR TEMPERATURE
```

```
C
C     *** OUTPUT ***
C
C         GD       = DAYTIME HEAT GAIN
C         GN       = NIGHTTIME HEAT GAIN
C
      DIMENSION SATD(2), SATN(2), TID(2), TIN(2), GD(2), GN(2)
      COMMON/LOOP/NL1,NL2,LUW
C
      DO 10 I=NL1,NL2
      GD(I)=U*A*(SATD(I)-TID(I)) * 12.0
      GN(I)=U*A*(SATN(I)-TIN(I)) * 12.0
   10 CONTINUE
      RETURN
      END
      SUBROUTINE HLHC(QID,QIN,QWD,QWN,QDD,QDN,QCD,QCN,QFD,QFN,
     *QRD,QRN,QTD,QTN,HG,HL,QCD,QCN,TIN,TON,TID,TOD,ICHECK
     *)
C     THIS IS HEAT LOSS AND HEAT GAIN CALCULATIONS 'HLHC'
C
C     ***  INPUT  ***
C     QCD  :  DAYTIME CEILING HEAT GAIN
C     QID  :  DAYTIME INFILTRATION HEAT GAIN
C     QIN  :  NIGHTTIME INFILTRATION HEAT GAIN
C     QWD  :  DAYTIME WALL HEAT GAIN
C     QWN  :  NIGHTTIME WALL HEAT GAIN
C     QDD  :  DAYTIME DOOR HEAT GAIN
C     QDN  :  NIGHTTIME DOOR HEAT GAIN
C     QCD  :  DAYTIME WINDOW HEAT GAIN
C     QCN  :  NIGHTTIME WINDOW HEAT GAIN
C     QFD  :  DAYTIME FLOOR HEAT GAIN
C     QFN  :  NIGHTTIME FLOOR HEAT GAIN
C     QRD  :  DAYTIME INTERNAL HEAT GAIN
C     QRN  :  NIGHTTIME INTERNAL HEAT GAIN
C     QCN  :  NIGHTTIME CEILING HEAT GAIN
C
C     ***  OUTPUT  ***
C     QTD  :  DAYTIME HEAT LOSS AND HEAT GAIN
C     QTN  :  NIGHTTIME HEAT LOSS AND HEAT GAIN
C     HL   :  DAILY HEAT LOSS
C     HG   :  DAILY HEAT GAIN
C
      DIMENSION QID(2),QIN(2), QWD(2), QWN(2), QDD(2), QDN(2),
     *QCD(2), QCN(2), QFD(2), QFN(2), QRD(2), QRN(2),
     *QTD(2), QTN(2), HG (2), HL (2), QCD(2), QCN(2),
     *TIN(2), TON(2), TID(2), TOD(2),
     *SCD(2)
      COMMON/LOOP/NL1,NL2,LUW
C
      DO 10 I=NL1,NL2
      HG(I)=0.0
      HL(I)=0.0
      QTD(I)=QID(I)+QWD(I)+QDD(I)+QCD(I)+QFD(I)+QRD(I)+QCD(I)
      QTN(I)=QIN(I)+QWN(I)+QDN(I)+QCN(I)+QFN(I)+QRN(I)+QCN(I)
C
      HGHL=QTD(I)+QTN(I)
      IF(HGHL.GT.0.0) HG(I)=HGHL
      IF(HGHL.LT.0.0) HL(I)=HGHL
   10 CONTINUE
      RETURN
      END
      SUBROUTINE BSMT(UFW,BWA,BFA,UFLR1,UFF,QBHG,TID,TIN,TG,TOD,TON,UBW,
     +        UBF,BSMTD,BSMTN,BQFD,BQFN)
C
C     THIS IS BASEMENT TEMPERATURE CALCULATION ' BSMT '
C
```

```
C       *** INPUT ***
C
C            BWA     = BASEMENT WALL AREA , FT**2
C            BFA     = BASEMENT FLOOR AREA , FT**2
C            UFLR1   = FLOOR HEAT TRANSFER COEFFICIENT , BTU/FT**2.F
C            UFF     = FLOOR-GROUND HEAT TRANSFER COEFFICIENT, =0.1
C            UFW     = WALL-GROUND HEAT TRANSFER COEFFICIENT, =0.164
C            QBHG    = BASEMENT HEAT GAIN FROM FUNACE, BOILER, OR OTHER
C                      EQUIPMENT, BTU/HR
C            TID     = DAYTIME TEMPERATURE OF THE ROOM ABOVE THE BASEMENT
C            TIN     = NIGHTTIME TEMPERATURE OF THE ROOM ABOVE THE BASEMENT
C
C
C
C       *** OUTPUT ***
C
C            BSMTD   = DAYTIME BASEMENT TEMPERATURE
C            BSMTN   = NIGHTTIME BASEMENT TEMPERATURE
C            BQFD
C            BQFN
C
        DIMENSION TID(2), TIN(2), BSMTD(2),BSMTN(2)
        DIMENSION TC(2),TOD(2),TON(2),BQFD(2),BQFN(2)
        COMMON/LOOP/NL1,NL2,LUW
        UW=UFW
        IF(UBW.EQ.0.0) GO TO 20
        UW=1.0/(1.0/UFW+1.0/UBW)
   20   UF=UFF
        IF(UBF.EQ.0.0) GO TO 30
        UF=1.0/(1.0/UFF+1.0/UBF)
   30   CONTINUE
        DO 10 I=NL1,NL2
        TO=(TOD(I)+TON(I))/2.0
        BSMTD(I)=(UW*TO*BWA+UF*TC(I)*BFA+UFLR1*TID(I)*BFA+QBHG)/(UW*BWA+
     +          UF*BFA+UFLR1*BFA)
        BSMTN(I)=(UW*TO*BWA+UF*TC(I)*BFA+UFLR1*TIN(I)*BFA+QBHG)/(UW*BWA+
     +          UF*BFA+UFLR1*BFA)
        BQFD(I)=(-UW*(TID(I)-TO)*BWA-UF*(TID(I)-TC(I))*BFA)*12.0
        BQFN(I)=(-UW*(TIN(I)-TO)*BWA-UF*(TIN(I)-TC(I))*BFA)*12.0
   10   CONTINUE
        RETURN
        END
        SUBROUTINE SOLDAT(ZKT,BB,H,WAZ,WTLT,XLAT,RHO,XIDT,XIDD)
C       THIS SUBROUTINE CALCULATES MONTHLY AVERAGE SOLAR HEAT RADIATION ON
C       SURFACE OF DIFFERENT ORIENTATIONS AND A HORIZONTAL , AND
C       HEAT GAIN THROUGH THE WINDOWS
C       ZKT...LIU/JORDAN FACTOR - DAILY TOTAL RADIATION ON A HORIZONTAL
C       SURFACE
C               THE SAME IN OUTER SPACE
C       H.....DAILY TOTAL RADIATION ON A HORIZONTAL SURFACE
C       TO....DAILY AVERAGE TEMPERATURE
C       XLAT..LATITUDE OF THE LOCATION
C       RHO...REFLECTIVITY OF THE GROUND AROUND THE WINDOW
C       WAZ...SURFACE AZIMUTH ANGLE, DEGREES FROM SOUTH   ( 0S, 90W, 180N,
C       -90E)
C       WTLT..SURFACE TILT ANGLE   (90 DEG VERTICAL, 0 DEG HORIZONTAL)
        REAL LAT
        REAL DNI(24),ASI(24),RSI(24),XIDT(2),XIDD(2)
        DIMENSION XDEC(2) , R(2) , ZIT(24)
       1,DLITE(2) , H(2) , ZKT(2) , B(2), BB(40)
        COMMON/LOOP/NL1,NL2,LUW
        DATA RST , PI /442.1 , 3.1415927 /
        XLAX=AINT(XLAT)
        LAT=(XLAX+(XLAT-XLAX)/0.6)*PI/180.
        WTLTX=WTLT*PI/180.
        WAZX=WAZ*PI/180.
```

```
      DO 1 N=NL1,NL2
      XDEC(N) = BB(N + 28)
      R(N) = BB(N + 30)
      B(N) = BB(N + 32)
      RD=AINT(XDEC(N))
      DEC=(RD+(XDEC(N)-RD)/0.6)*PI/180.
      COSWS=-TAN(LAT)*TAN(DEC)
      IF(COSWS.GT.1..OR.COSWS.LT.-1.) RETURN
      WS=ACOS(COSWS)
      TWS=WS*12/PI
      SUNRIZ=12.-ABS(TWS)
      SUNSET=12.+ABS(TWS)
      COSLD=COS(LAT)*COS(DEC)
      SINLD=SIN(LAT)*SIN(DEC)
      S=0.
      DO 500 L=1,39
      WW=WS*L/40.
      CZE=COSLD*COS(WW)+SINLD
      PAR=-B(N)/CZE
      APA=ABS(PAR)
      IF(APA.GT.80.) GO TO 501
      ANS=EXP(PAR)*CZE
      GO TO 502
  501 ANS=0.
  502 S=ANS+S
  500 CONTINUE
      ANSO=EXP(-B(N)/(COSLD+SINLD))*(COSLD+SINLD)/2.
      AI=WS/ 40.*(ANSO+S)
      HO=24./PI*R(N)*RST*(COSLD*SIN(WS)+WS*SINLD)
C------------- DAILY TOTAL HORIZONTAL
      ZKT(N) = H(N)/HO
      ZKD=ZD(ZKT(N))
C------------- DAILY TOTAL DIRECT ON HORIZONTAL
      DHH=HO*(ZKT(N)-ZKD)
C------------- DAILY TOTAL DIFFUSE ON HORIZONTAL
      RHH=HO*ZKD
      A=DHH/(24./PI*AI)
      DO 2 I=1,24
      DNI(I)=0.
      ASI(I)=0.
      RSI(I)=0.
    2 ZIT(I)=0.
      DLITE(N)=2.*ABS(TWS)
      DO 3 I=1,24
      TIME=I-1.
      WT=ABS(12.-TIME)
      W=WT*PI/12.
      IF(TIME-SUNRIZ) 3,3,4
    4 IF(TIME-SUNSET) 5,3,3
    5 COSZ=SINLD+COSLD*COS(W)
      COSW=COS(DEC)*SIN(W)
      COSS=SQRT(1.-COSW*COSW-COSZ*COSZ)
      V=TAN(DEC)/TAN(LAT)
      TEST=COS(W)-V
      IF(TEST) 9,9,8
    9 COSS=-COSS
    8 ALT=ASIN(COSZ)
      AZM=ASIN(COSW/COS(ALT))
      IF(COSS) 23,24,24
   23 AZM=PI-AZM
   24 IF(AZM.GT.PI) AZM=2.*PI-AZM
      IF(TIME.LT.12.) AZM=-AZM
      PAR2=-B(N)/COSZ
      AP2=ABS(PAR2)
      IF(AP2.GT.80.) GO TO 3
      DNI(I)=A*EXP(PAR2)
```

```
      IF(DNI(I).LE.0.) DNI(I)=0.
      DHI=DNI(I)*COSZ
      IF(DHI.LE.0.) DHI=0.
      RR=PI/24.*(COS(W)-COS(WS))/(SIN(WS)-WS*COS(WS))
      IF(RR.LT.0.) RR=0.
      RHI=RHH*RR
      IF(WTLT.GT.0.) GO TO 25
      COSTH=COSZ
      GO TO 26
   25 CONTINUE
      SAZM=AZM-WAZX
      IF(WTLT.GE.90.) GO TO 50
      ALPHA=COS(WTLTX)
      BETA=SIN(WAZX)*SIN(WTLTX)
      GAMMA=COS(WAZX)*SIN(WTLTX)
      COSTH=ALPHA*COSZ+BETA*COSW+GAMMA*COSS
      GO TO 26
   50 COSTH=COS(SAZM)*COS(ALT)
   26 CONTINUE
      IF(COSTH.LE.0.) COSTH=0.
      ASI(I)=DNI(I)*COSTH
      IF(ASI(I).LE.0.) ASI(I)=0.
      RSI(I)=(RHI+(RHI+DHI)*RHO)/2.
      IF(WTLT.LE.0.) RSI(I)=RHI
      ZIT(I)=ASI(I)+RSI(I)
    3 CONTINUE
      SUMN=0.
      SUMD=0.
      SUMR=0.
      SUM=0.
      DO 14 I=1,24
      SUMN=SUMN+DNI(I)
      SUMD=SUMD+ASI(I)
      SUMR=SUMR+RSI(I)
   14 SUM=SUM+ZIT(I)
      XIDT(N)=SUMD+SUMR
      XIDD(N)=SUMR
    1 CONTINUE
      RETURN
      END
      FUNCTION ZD(ZT)
      DIMENSION ZKT(6) , ZKD(6)
      DATA ZKT/.3,.4,.5,.6,.7,.75/
      DATA ZKD /.179 , .183 , .188 , .174 , .149 , .125 /
      IF(ZT-0.3) 1,1,2
    1 ZD=.179
      GO TO 10
    2 IF(ZT-0.75) 3,3,4
    4 ZD=.125
      GO TO 10
    3 DO 20 J=2,6
      T1=ZT-ZKT(J-1)
      T2=ZT-ZKT(J)
      TEST=T1*T2
      IF(TEST) 5,6,20
    5 Y1=ZKD(J-1)
      Y2=ZKD(J)
      ZD=Y1+(Y2-Y1)*(ZT-ZKT(J-1))/(ZKT(J)-ZKT(J-1))
      GO TO 20
    6 IF(T1) 8,9,8
    9 ZD=ZKD(J-1)
      GO TO 20
    8 ZD=ZKD(J)
   20 CONTINUE
   10 RETURN
      END
```

```
      SUBROUTINE PSY2 (DB,DP,PB,WB,PV,W,H,V,RH)
C
C     ****************************************************************
C
C     THIS SUBROUTINE CALCULATES THE FOLLOWINGS WHEN DRY-BULB TEMPERATURE
C     (DB),DEW-POINT TEMPERATURE(DP),AND BAROMETRIC PRESSURE(PB) ARE GIVEN
C     WB    WET-BULB TEMPERATURE
C     W     HUMIDITY RATIO
C      H    ENTHALPY
C      V    VOLUME
C     PV    VAPOR PRESSURE
C     RH    RELATIVE HUMIDITY
      IF (DP-DB) 20,10,10
10    DP=DB
20    PV=PVSF(DP)
      PVS=PVSF(DB)
      RH=PV/PVS
      W=0.622*PV/(PB-PV)
      V=0.754*(DB+459.7)*(1+7000*W/4360)/PB
      H=0.24*DB+(1061+0.444*DB)*W
      IF (H) 30,30,40
30    W3=DP
      RETURN
C
40    WB=WBF(H,PB)
      RETURN
C
      END
      SUBROUTINE DBRH (DB,RH,W)
C
C     ****************************************************************
C
      PVS=PVSF(DB)
      PV=RH*PVS/100.
      W=0.622*PV/(29.92-PV)
      RETURN
C
      END
      FUNCTION PVSF (X)
C
C     ****************************************************************
C
      REAL LOG10
      DIMENSION A(6) , B(4) , P(4)
      DATA A/-7.90298,5.02808,-1.3816E-7,11.344,8.1328E-3,-3.49149/
      DATA B/-9.09718,-3.56654,0.876793,0.0060273/
      LOG10(XX) = ALOG10(XX)
      T=(X+459.688)/1.8
      IF (T.LT.273.16) GO TO 10
      Z=373.16/T
      P(1)=A(1)*(Z-1)
      P(2)=A(2)*LOG10(Z)
      Z1=A(4)*(1-1/Z)
      P(3)=A(3)*(10**Z1-1)
      Z1=A(6)*(Z-1)
      P(4)=A(5)*(10**Z1-1)
      GO TO 20
C
10    Z=273.16/T
      P(1)=B(1)*(Z-1)
      P(2)=B(2)*LOG10(Z)
      P(3)=B(3)*(1-1/Z)
      P(4)=LOG10(B(4))
20    SUM=0
      DO 30 I=1,4
30    SUM=SUM+P(I)
```

```
      PVSF=29.921*10**SUM
      RETURN
C
      END
      FUNCTION WBF (H,PB)
C
C     ****************************************************************
C
C  THIS PROGRAM APPROXIMATES THE WET-BULB TEMPERATURE WHEN
C   ENTHALPY IS GIVEN
      IF (H) 30,30,10
   10 Y = ALOG(H)
      IF (H.GT.11.758) GO TO 20
      WBF=0.6041+3.4841*Y+1.3601*Y*Y+0.97307*Y*Y*Y
      GO TO 100
C
20    WBF=30.9185-39.68200*Y+20.5841*Y*Y-1.758*Y*Y*Y
      GO TO 100
C
30    WB1=150.
      PV1=PVSF(WB1)
      W1=0.622*PV1/(PB-PV1)
      X1=0.24*WB1+(1061+0.444*WB1)*W1
      Y1=H-X1
40    WB2=WB1-1
      PV2=PVSF(WB2)
      W2=0.622*PV2/(PB-PV2)
      X2=0.24*WB2+(1061+0.444*WB2)*W2
      Y2=H-X2
      IF (Y1*Y2) 90,60,50
50    WB1=WB2
      Y1=Y2
      GO TO 40
C
60    IF (Y1) 80,70,80
70    WBF=WB1
      GO TO 100
C
80    WBF=WB2
      GO TO 100
C
90    Z=ABS(Y1/Y2)
      WBF=(WB2*Z+WB1)/(1+Z)
100   RETURN
C
      END
      SUBROUTINE HCLD (B,BB)
C
C     **********          **********          ***********
C
C     PROJECT CONSERVE HEATING/COOLING LOAD DETERMINATION
C
C     **********          **********          ***********
C
      DIMENSION  TOD(2),  TON(2),  TID(2),  TIN(2),RINFLD(2),
     *RINFLN(2), BB(40),
     1RH(2,2), QISD(2), QISN(2),QILD(2), QILN(2),
     2XIDT(2), XIDD(2), QGD1(2), QGN1(2), QGD2(2), QGN2(2),
     3QGD3(2), QGN3(2), QGD4(2), QGN4(2), QGD(2), QGN(2),
     4QS(2), SATD(2), SATN(2), GD1(2), GN1(2), GD2(2),
     5GN2(2), GD3(2), GN3(2), GD4(2), GN4(2), QDD(2),
     6QDN(2), QCD(2), QCN(2),  TWD1(2), TWN1(2),
     7ATD(2), ATN(2), QFD(2), QFN(2),CRAWLD(2),CRAWLN(2),
     8QRD(2), QRN(2),TOT(2),B(100),
     9QID(2), QIN(2), QTD(2), QTN(2), HC(2), HL(2),
     ARLHC(2), HREQ(2), CREQ(2),
```

```
      BQWD(2), QWN(2), ZT(2),
      CTE(2), TG(2), H(2), BSMTD(2), BSMTN(2)
      D,TWD2(2), TWN2(2), TWD(2), TWN(2)
       DIMENSION DAYS(2),AA(28)
       DIMENSION SCD(2),SCD1(2),SCD2(2),SCD3(2),SCD4(2)
       DIMENSION XIDTS(2),XIDDS(2),XIDTW(2),XIDDW(2),
      1XIDTN(2),XIDDN(2),XIDTE(2),XIDDE(2)
      2,BQFD(2),BQFN(2),ATQCD(2),ATQCN(2),
      3QDD1(2),QDN1(2),QDD2(2),QDN2(2),QDD3(2),
      4QDN3(2),QDD4(2),QDN4(2),
      5XT901(2),XD901(2),XT902(2),XD902(2),
      6XT903(2),XD903(2),XT904(2),XD904(2)
      7,RHM(2),RHA(2),XX(2),WSD(2),WSN(2), FO(2)
       COMMON/LOOP/NL1,NL2,LUW
       REAL NPD,NPN
C
       DATA AA/3HTID,3HTIN,3HTOD,3HTON,5HXIDTS,5HXIDDS,5HXIDTW,5HXIDDW,
      15HXIDTN,5HXIDDN,5HXIDTE,5HXIDDE,3HQID,3HQIN,3HQWD,3HQWN,3HQDD,
      23HQDN,3HQCD,3HQCN,3HQCD,3HQCN,3HQFD,3HQFN,3HQRD,3HQRN,3HQTD,3HQTN
      3/
       HREQ(1)=0.0
       CREQ(2)=0.0
       DOOR13=B(76)
       DOOR14=B(77)
       DOOR15=B(78)
       DOOR16=B(79)
       DOOR23=B(80)
       DOOR24=B(81)
       DOOR25=B(82)
       DOOR26=B(83)
       DOOR33=B(84)
       DOOR34=B(85)
       DOOR35=B(86)
       DOOR36=B(87)
       DOOR43=B(88)
       DOOR44=B(89)
       DOOR45=B(90)
       DOOR46=B(91)
       ICHECK=B(92)
       IFURN = IFIX(B(94))
       FEFF = B(95)
       FO(1)=BB(35)
       FO(2)=BB(36)
C      (INFIL) VOLUME OF THE ROOM.   L.W.H.
       V = B(1)
C      (INFIL) STD AIR CHANGE DATA, AC/HR
       ACHS = B(2)
       DO 10 I=1,2
C      DAYTIME OUTDOOR TEMPERATURE TOD
       TOD(I)=BB(I)
       TON(I)=BB(2+I)
C      DAYTIME INDOOR TEMP  RMDBS/W
       TID(I)=BB(I+4)
C      NIGHTTIME INDOOR TEMP  RMDBS/W
   10  TIN(I) = BB(I+6)
       DO 20 I=1,2
C      (INFIL) WIND SPEED, MPH
       WSD(I) = BB(I+8)
       WSN(I) = BB(I+10)
C      (SOLDAT) LIU/JORDAN' FACTOR
       ZT(I) = BB(I+14)
C      (SOLDAT) DAILY TOTAL RADIATION ON A HORIZ.
       H(I) = BB(I+16)
C      SURFACE (BTU/FT2)
   20  CONTINUE
C      ORIENTATION (0S,90W,180N,270E) AZW
```

```
      ORT1 = B(3)
C     LAT
      XLAT = B(4)
C     (SOLDAT)
      RHO = B(5)
C     (SOLDAT) NOT USED---ALPHANUMERIC TITLE
C     (QG) GLASS AREA   A
      AG1 = B(6)
C     (QG)  SHADING COEFFICIENT  SHADE
      SC1 = B(7)
C     (QG)  HEAT TRANSFER COEFFICIENT U
      UG1 = B(8)
C     (QG)  EXTERNAL SHADOW FACTOR SHDW
      SHDW1 = B(9)
      ORT2 = B(10)
      AG2 = B(11)
      SC2 = B(12)
      UG2 = B(13)
      SHDW2 = B(14)
      ORT3 = B(15)
      AG3 = B(16)
      SC3 = B(17)
      UG3 = B(18)
      SHDW3 = B(19)
      ORT4 = B(20)
      AG4 = B(21)
      SC4 = B(22)
      UG4 = B(23)
      SHDW4 = B(24)
C SHDW (QG,SAT) EXTERNAL SHADOW FACTOR (0.0 - 1.0)
      WALL13 = B(25)
C AB (SAT) SURFACE ABSORPTIVITY ABSP
      WALL14= B(26)
C U (QECHG) OVERALL HEAT TRANSFER COEFFICIENT
      WALL15 = B(27)
C A (QECHG) AREA
      WALL16 = B(28)
C SHDW
      WALL23 = B(29)
C AB
      WALL24 = B(30)
C U
      WALL25 = B(31)
C A
      WALL26 = B(32)
C SHDW
      WALL33 = B(33)
C AB
      WALL34 = B(34)
C U
      WALL35 = B(35)
C A
      WALL36 = B(36)
C SHDW
      WALL43 = B(37)
C AB
      WALL44 = B(38)
C U
      WALL45 = B(39)
C A
      WALL46 = B(40)
      SOGFRC = B(41)
      CRWFRC = B(42)
      BSMFRC = B(43)
C SHDW (SAT) ATTICLESS
      ROOF1 = B(45)
```

```
C AB (SAT) ATTICLESS
      ROOF2 = B(46)
C U / UR (QECHG/ATTIC)  ATTICLESS/WITH ATTIC
      ROOF3 = B(47)
      AEWH = B(48)
      ROOF4 = B(44)
      AW = B(49)
      ACAT=B(50)
C UC / U (ATTIC/QECHG)  U-VALUE CLG / HTC UCELNG
      UCEIL = B(51)
C UW / A (ATTIC/QECHG)  U-VALUE WALL/AREA UENDW/A
      AEWS = B(52)
C U (GF) FLOOR HEAT TRANSFER COEFF. (HTC)
      UFLR1 = B(53)
      INDEXD = B(54)
      INDEXC = B(55)
C EXPOSED PERIMETER LENGTH OF THE FLOOR
      ZL = B(56)
      DO 50 I=1,2
C     (CRAWL.GF) GROUND TEMP. SEASONAL TGS/TGW
   50 TG(I) = BB(I+12)
      ACCS=B(57)
C UF / U (CRAWL/QECHG) FLOOR HTC/OVERALL HTC U
      UFLR2 = B(58)
C UW / U (CRAWL/QECHG) WALL HTC/OVERALL HTC U
      UCLW = B(59)
      HCL = B(60)
C AW / A (CRAWL/QECHG) CRAWL SPACE WALL AREA A
      AWCL = B(61)
C     (QR) NO. DAYTIME OCCUPANTS  QOCUP
      NPD = B(62)
C     (QR) NO. NIGHTTIME OCCUPANTS  QOCUP
      NPN = B(63)
C     (QR) AVG. DAYTIME LIGHTING  QLITX
      WTD = B(64)
C     (QR) AVG. NIGHTTIME LIGHTING  QLITX
      WTN = B(65)
C     (QR) AVG. DAYTIME EQUIPMENT  QEQUX
      WED = B(66)
C     (QR) AVG. NIGHTTIME EQUIPMENT  QEQUX
      WEN = B(67)
C AF (QR) FLOOR AREA
      FLOORA = B(68)
      ATFLR = B(69)
      UBW = B(70)
C     (EREQ) SYSTEM INDEX
      UFW = B(71)
C     (BSMT) BASEMENT WALL AREA
      BWA = B(72)
      UBF = B(73)
      UFF = B(74)
C     (BSMT) HEAT GAIN FROM FURNACE, BOILER, ETC
      QBHC = B(75)
      DO 80 I=1,2
      RH(1,I) = BB(I + 18)
      RH(2, I) = BB(I + 20)
   80 CONTINUE
      RHM(1) = BB(23)
      RHM(2) = BB(24)
      RHA(1) = BB(25)
      RHA(2) = BB(26)
      DAYS(1) = BB(27)
      DAYS(2) = BB(28)
      DO 60 I=NL1,NL2
      IF(TIN(I).GT.TID(I)) TIN(I)=TID(I)
   60 CONTINUE
```

```
      CALL PRNTIN(B,BB)
      GO TO 9901
   90 FORMAT(10(I4,F9.3))
   91 WRITE(LUW,92) (TID(I), TIN(I), I=NL1,NL2)
   92 FORMAT(F8.4,5X,F8.4)
 9901 CONTINUE
C
C01    ** INFILTRATION HEAT GAIN **
      CALL INFIL (V,ACHS,TOD,TON,TID,TIN,WSD,WSN,RINFLD,RINFLN)
      CALL QI (RINFLD, RINFLN, TOD, TON, TID, TIN, RH,QISD,QISN,QILD,
     1QILN,RHM,RHA)
C
      IF(ICHECK.EQ.1) WRITE(LUW,8001)
 8001 FORMAT(1H ,'INFILTRATION HEAT GAIN ROUTINE COMPLETED')
C02 ** WINDOW HEAT GAIN **  WINDOW NO. 1 TO 4
      DO 304 I =NL1,NL2
      QCD1(I)=0.0
      QCN1(I)=0.0
      QCD2(I)=0.0
      QCN2(I)=0.0
      QCD3(I)=0.0
      QCN3(I)=0.0
      QCD4(I)=0.0
      QCN4(I)=0.0
      SCD1(I)=0.0
      SCD2(I)=0.0
      SCD3(I)=0.0
      SCD4(I)=0.0
  304 CONTINUE
      TILT=90.0
      CALL SOLDAT(ZT, BB, H, ORT1, TILT, XLAT, RHO,  XT901, XD901)
      IF(AG1.EQ.0.0) GO TO 305
      CALL QG (AG1, SC1, UG1, TOD, TON, TID, TIN, SHDW1, XT901,XD901,
     1QCD1, QCN1, SCD1)
  305 DO 300 I=NL1,NL2
      XIDTN(I)=XT901(I)
      XIDDN(I)=XD901(I)
  300 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8002)
 8002 FORMAT(1H ,'WINDOW HEAT GAIN ROUTINE NO1. COMPLETED')
      CALL SOLDAT(ZT, BB, H, ORT2, TILT, XLAT, RHO,  XT902,XD902)
      IF(AG2.EQ.0.0) GO TO 306
      CALL QG (AG2, SC2, UG2, TOD, TON, TID, TIN, SHDW2, XT902,XD902,
     1QCD2, QCN2, SCD2)
  306 DO 301 I=NL1,NL2
      XIDTE(I)=XT902(I)
      XIDDE(I)=XD902(I)
  301 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8003)
 8003 FORMAT(1H ,'WINDOW HEAT GAIN ROUTINE NO2. COMPLETED')
      CALL SOLDAT(ZT, BB, H, ORT3, TILT, XLAT, RHO,  XT903,XD903)
      IF(AG3.EQ.0.0) GO TO 307
      CALL QG (AG3, SC3, UG3, TOD, TON, TID, TIN, SHDW3, XT903,XD903,
     1QCD3, QCN3, SCD3)
  307 DO 302 I=NL1,NL2
      XIDTS(I)=XT903(I)
      XIDDS(I)=XD903(I)
  302 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8004)
 8004 FORMAT(1H ,'WINDOW HEAT GAIN ROUTINE NO3. COMPLETED')
      CALL SOLDAT(ZT, BB, H, ORT4, TILT, XLAT, RHO,  XT904,XD904)
      IF(AG4.EQ.0.0) GO TO 308
      CALL QG (AG4, SC4, UG4, TOD, TON, TID, TIN, SHDW4, XT904,XD904,
     1QCD4, QCN4, SCD4)
  308 DO 303 I=NL1,NL2
      SCD(I)=SCD1(I)+SCD2(I)+SCD3(I)+SCD4(I)
```

```
      XIDTW(I)=XT904(I)
      XIDDW(I)=XD904(I)
  303 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8005)
 8005 FORMAT(1H ,'WINDOW HEAT GAIN ROUTINE NO4. COMPLETED')
      DO 102 I =NL1,NL2
      QCD(I)=QCD1(I)+QCD2(I)+QCD3(I)+QCD4(I)
      QCN(I)=QCN1(I)+QCN2(I)+QCN3(I)+QCN4(I)
  102 CONTINUE
C
      DO 103 I=NL1,NL2
  103 QS(I)=QS(I)*DAYS(I)
      IF(ICHECK.EQ.1) WRITE(LUW,8006)
 8006 FORMAT(1H ,'SOLAR ENERGY UTILIZATION ROUTINE COMPLETED')
C
C 04 ** WALL HEAT GAIN ** WALL NO. 1 TO 4
      DO 401 I=NL1,NL2
      GD1(I)=0.0
      GN1(I)=0.0
      GD2(I)=0.0
      GN2(I)=0.0
      GD3(I)=0.0
      GN3(I)=0.0
      GD4(I)=0.0
      GN4(I)=0.0
  401 CONTINUE
      IF(WALL16.EQ.0.0) GO TO 402
      CALL SAT(XT901,XD901,WALL13,WALL14,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,WALL15,WALL16,TID,TIN,GD1,GN1)
  402 IF(WALL26.EQ.0.0) GO TO 403
      CALL SAT(XT902,XD902,WALL23,WALL24,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,WALL25,WALL26,TID,TIN,GD2,GN2)
  403 IF(WALL36.EQ.0.0) GO TO 404
      CALL SAT(XT903,XD903,WALL33,WALL34,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,WALL35,WALL36,TID,TIN,GD3,GN3)
  404 IF(WALL46.EQ.0.0) GO TO 405
      CALL SAT(XT904,XD904,WALL43,WALL44,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,WALL45,WALL46,TID,TIN,GD4,GN4)
  405 DO 104 I=NL1,NL2
      QWD(I)=GD1(I)+GD2(I)+GD3(I)+GD4(I)
      QWN(I)=GN1(I)+GN2(I)+GN3(I)+GN4(I)
  104 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8007)
 8007 FORMAT(1H ,'WALL HEAT GAIN ROUTINE COMPLETED')
C
C 05 ** DOOR HEAT GAIN **
      DO 500 I=NL1,NL2
      QDD1(I)=0.0
      QDN1(I)=0.0
      QDD2(I)=0.0
      QDN2(I)=0.0
      QDD3(I)=0.0
      QDN3(I)=0.0
      QDD4(I)=0.0
      QDN4(I)=0.0
  500 CONTINUE
      IF(DOOR16.EQ.0.0) GO TO 501
      CALL SAT(XT901,XD901,DOOR13,DOOR14,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,DOOR15,DOOR16,TID,TIN,QDD1,QDN1)
  501 IF(DOOR26.EQ.0.0) GO TO 502
      CALL SAT(XT902,XD902,DOOR23,DOOR24,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,DOOR25,DOOR26,TID,TIN,QDD2,QDN2)
  502 IF(DOOR36.EQ.0.0) GO TO 503
      CALL SAT(XT903,XD903,DOOR33,DOOR34,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,DOOR35,DOOR36,TID,TIN,QDD3,QDN3)
  503 IF(DOOR46.EQ.0.0) GO TO 504
```

```
      CALL SAT(XT904,XD904,DOOR43,DOOR44,FO,90.0,TOD,TON,SATD,SATN)
      CALL QECHG(SATD,SATN,DOOR45,DOOR46,TID,TIN,QDD4,QDN4)
  504 CONTINUE
      DO 505 I =NL1,NL2
      QDD(I)=QDD1(I)+QDD2(I)+QDD3(I)+QDD4(I)
      QDN(I)=QDN1(I)+QDN2(I)+QDN3(I)+QDN4(I)
  505 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8008)
 8008 FORMAT(1H ,'DOOR HEAT GAIN ROUTINE COMPLETED')
C
C 06 ** CEILING HEAT GAIN **
C
      DO 16 I=NL1,NL2
      XX(I) = 0.0
      QCD(I)=0.0
      QCN(I)=0.0
   16 CONTINUE
C     ATTICLESS ROOFS
      TILT=0.0
      CALL SOLDAT(ZT, BB,H,0.0,TILT,XLAT,RHO,XIDT,XIDD)
      CALL SAT(XIDT,XIDD,ROOF1,ROOF2,FO,0.0,TOD,TON,SATD,SATN)
      IF(ROOF4.EQ.0.0) GO TO 6
      CALL QECHG(SATD,SATN,ROOF3,ROOF4,TID,TIN,QCD,QCN)
      IF(ICHECK.EQ.1) WRITE(LUW,8009)
 8009 FORMAT(1H ,'ATTICLESS ROOFS ROUTINE COMPLETED')
    6 IF(ATFLR.EQ.0.0) GO TO 66
C     ATTIC ROOFS
      DO 600 I=NL1,NL2
      ATD(I)=TID(I)
      ATN(I)=TIN(I)
  600 CONTINUE
      CALL SAT(XX,XX,0.0,0.0,FO,90.0,TOD,TON,TWD1,TWN1)
      CALL SAT(XX,XX,0.0,0.0,FO,90.0,TOD,TON,TWD2,TWN2)
      DO 666 I =NL1,NL2
      TWD(I) = (TWD1(I) + TWD2(I))/ 2.0
      TWN(I) = (TWN1(I) + TWN2(I))/ 2.0
  666 CONTINUE
      IF(INDEXD.EQ.0) GO TO 601
      CFM=ACAT*ATFLR*AEWH/60.0
      CALL ATTIC(ATFLR,SATD,SATN,ATFLR,TID,TIN,AW,TWD,TWN,CFM,ROOF3,
     *UCEIL,AEW5,TOD,TON,ATD,ATN)
  601 IF(ICHECK.NE.1) GO TO 9902
      WRITE(LUW,9001)(ATD(K),ATN(K),TWD(K),TWN(K),SATD(K),SATN(K),
     1 K=NL1,NL2)
 9001 FORMAT(1H ,6(F9.3))
 9902 CONTINUE
      CALL QECHG(ATD,ATN,UCEIL,ATFLR,TID,TIN,ATQCD,ATQCN)
      GO TO 6666
   66 DO 166 I=NL1,NL2
      ATQCD(I)=0.0
      ATQCN(I)=0.0
  166 CONTINUE
 6666 DO 106 I=NL1,NL2
      QCD(I)=QCD(I)+ATQCD(I)
      QCN(I)=QCN(I)+ATQCN(I)
  106 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8010)
 8010 FORMAT(1H ,'CEILING HEAT GAIN ROUTINE COMPLETED')
C
C 07 ** FLOOR HEAT GAIN **
C
C     SLAB ON GRADE
      AF=FLOORA*SOGFRC
      DO 177 I=NL1,NL2
      QFD(I)=0.0
      QFN(I)=0.0
```

```
  177 CONTINUE
      IF(AF.EQ.0.0) GO TO 7
      CALL GF(AF,ZL,TG,TOD,TON,UFF,TID,TIN,QFD,QFN)
      IF(ICHECK.EQ.1) WRITE(LUW,8011)
 8011 FORMAT(1H ,'SLAB ON GRADE ROUTINE COMPLETED')
C     CRAWL SPACE
    7 DO 701 I=NL1,NL2
      CD1(I)=0.0
      CN1(I)=0.0
      CD2(I)=0.0
      CN2(I)=0.0
  701 CONTINUE
      AFCL=FLOORA*CRWFRC
      IF(AFCL.EQ.0.0) GO TO 702
      CALL SAT(XX,XX,0.0,0.0,FO,90.0,TOD,TON,SATD,SATN)
      CFMM=ACCS*FLOORA*CRWFRC*HCL/60.0
      CALL CRAWL(TOD,TON,TG,TID,TIN,SATD,SATN,CFMM,UFLR2,UCLW,1.6,AFCL.
     *AWCL,CRAWLD,CRAWLN)
      CALL QECHG(CRAWLD,CRAWLN,UFLR2,AFCL,TID,TIN,CD1,CN1)
  702 DO 107 I=NL1,NL2
      QFD(I)=CD1(I)+CD2(I)+QFD(I)
      QFN(I)=CN1(I)+CN2(I)+QFN(I)
  107 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8012)
 8012 FORMAT(1H ,'CRAWL SPACE ROUTINE COMPLETED')
      BFA=FLOORA*BSMFRC
      DO 703 I=NL1,NL2
      BQFD(I)=0.0
      BQFN(I)=0.0
  703 CONTINUE
      IF(BFA.EQ.0.0) GO TO 704
C     BASEMENT
      CALL BSMT (UFW,BWA,BFA,UFLR1,UFF,QBHG,TID,TIN,TG,TOD,TON,
     1UBW,UBF,BSMTD,BSMTN,BQFD,BQFN)
      IF(ICHECK.EQ.1) WRITE(LUW,9999) (BSMTD(I),I=NL1,NL2)
 9999 FORMAT(/1H ,5X,G10.4,7X,G10.4)
      IF(ICHECK.EQ.1) WRITE(LUW,9999) (BSMTN(I),I=NL1,NL2)
      IF(INDEXC.NE.0)CALL QECHG(BSMTD,BSMTN,UFLR1,BFA,TID,TIN,
     1BQFD,BQFN)
      IF(ICHECK.EQ.1) WRITE(LUW,9999) (BQFD(I),I=NL1,NL2)
      IF(ICHECK.EQ.1) WRITE(LUW,9999) (BQFN(I),I=NL1,NL2)
      IF(ICHECK.EQ.1) WRITE(LUW,8013)
 8013 FORMAT(1H ,'BASEMENT ROUTINE COMPLETED')
  704 DO 1777 I=NL1,NL2
      QFD(I)=QFD(I)+BQFD(I)
      QFN(I)=QFN(I)+BQFN(I)
 1777 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,8014)
 8014 FORMAT(1H ,'FLOOR HEAT GAIN ROUTINE COMPLETED')
C
C 08 ** INTERNAL HEAT GAIN  **
      CALL QR(NPD,NPN,WTD,WTN,WED,WEN,QRSD,QRSN,QRLD,QRLN)
      IF(ICHECK.EQ.1) WRITE(LUW,8015)
 8015 FORMAT(1H ,'INTERNAL HEAT GAIN ROUTINE COMPLETED')
C
C 09  ** HEAT LOSS AND HEAT GAIN  **
      DO 109 I=NL1,NL2
      QRD(I)=QRSD
      QRN(I)=QRSN
      QID(I)=QISD(I)
      QIN(I)=QISN(I)
  109 CONTINUE
      IF(ICHECK.NE.1) GO TO 9900
      WRITE(LUW,9005)
 9005 FORMAT(1H1,33X,'VALUES FOR BILLING PERIOD')
      WRITE(LUW,9006)
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 9006 FORMAT(1H ,55X,25(1H-))
      WRITE(LUW,9007)
 9007 FORMAT(/1H ,5X,'HEATING DAYS',5X,'COOLING DAYS'/)
      WRITE(LUW,9003) AA(1),(TID(I),I=NL1,NL2)
 9003 FORMAT(1H ,A5,G10.4,7X,G10.4)
      WRITE(LUW,9003) AA(2),(TIN(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(3),(TOD(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(4),(TON(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(5),(XIDTS(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(6),(XIDDS(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(7),(XIDTW(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(8),(XIDDW(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(9),(XIDTN(I),I=NL1,NL2)
      WRITE(LUW,9003) AA(10),(XIDDN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(11),(XIDTE(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(2),(XIDDE(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(13),(QID(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(14),(QIN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(15),(QWD(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(16),(QWN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(17),(QDD(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(18),(QDN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(19),(QCD(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(20),(QCN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(21),(QGD(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(22),(QGN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(23),(QFD(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(24),(QFN(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(25),(QRD(I),I=NL1,NL2)
      WRITE(LUW,9003)AA(26),(QRN(I),I=NL1,NL2)
 9004 FORMAT(/1H ,A5,G10.4,7X,G10.4)
 9900 CONTINUE
C
C
C
      CALL HLHC(QID,QIN,QWD,QWN,QDD,QDN,QCD,QCN,QFD,QFN,QRD,QRN
     *,QTD,QTN,HC,HL,QCD,QCN,TIN,TON,TID,TOD,
     *ICHECK)
      IF(ICHECK.NE.1) GO TO 9010
      WRITE(LUW,9004)AA(27),(QTD(I),I=NL1,NL2)
      WRITE(LUW,9004)AA(28),(QTN(I),I=NL1,NL2)
 9002 FORMAT(1X,14E9.4)
 9010 CONTINUE
      IF (ICHECK.EQ.1) WRITE(LUW,8016)
 8016 FORMAT(1H ,'HEAT LOSS + HEAT GAIN ROUTINE COMPLETED')
C
C10 **  HEATING AND COOLING REQUIREMENT **
      DO 110 I=NL1,NL2
      RLHC(I)=0.0
      IF(QRLD.GT.0.0) RLHC(I)=RLHC(I)+QRLD
      IF(QRLN.GT.0.0) RLHC(I)=RLHC(I)+QRLN
      IF(IJ.GE.1.AND.TON(I).LT.TID(I).AND.
     1QRLD.GT.0.0.AND.IACNV.EQ.1) RLHC(I)=RLHC(I)-QRLD
      IF(IJ.GE.1.AND.TON(I).LT.TIN(I).AND.
     1QRLN.GT.0.0.AND.IACNV.EQ.1) RLHC(I)=RLHC(I)-QRLN
      IF(QILD(I).GT.0.0) RLHC(I)=RLHC(I)+QILD(I)
      IF(QILN(I).GT.0.0) RLHC(I)=RLHC(I)+QILN(I)
      IF(IJ.GE.1.AND.TOD(I).LT.TID(I).AND.
     1QILD(I).GT.0.0.AND.IACNV.EQ.1) RLHC(I)=RLHC(I)-QILD(I)
      IF(IJ.GE.1.AND.TON(I).LT.TIN(I).AND.
     1QILN(I).GT.0.0.AND.IACNV.EQ.1) RLHC(I)=RLHC(I)-QILN(I)
  110 CONTINUE
      IF(ICHECK.EQ.1) WRITE(LUW,9011) (RLHC(I),I=NL1,NL2)
 9011 FORMAT(/1H ,'RLHC ',G10.4,7X,G10.4)
C
      CALL HCRT(HL,HG,RLHC,HREQ,CREQ)
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      DO 200 I=NL1,NL2
      HREQ(I) = HREQ(I) * DAYS(I)
      CREQ(I) = CREQ(I) * DAYS(I)
  200 CONTINUE
  203 CONTINUE
C     CONVERT HREQ AND CREQ TO MILLIONS OF BTU
      HRMBTU = HREQ(1)/1.E6
      CRMBTU = CREQ(2)/1.E6
      WRITE(LUW,9020)
 9020 FORMAT(1H1,50X,'SIMULATION RESULTS'/
     +       1H ,50X,18(1H-))
      WRITE(LUW,9008) HRMBTU,CRMBTU
 9008 FORMAT(////1H ,5X,'HEATING REQ ',5X,'COOLING REQ ',
     +       5X,'(MILLIONS OF BTU)'/1H ,5X,11(1H-),
     +       6X,11(1H-)//1H ,5X,G10.4,7X,G10.4)
C
      DO 800 I = NL1, NL2
         IF (I .GT. 1) GO TO 890
         DUMA = 1.E6 * ABS(HRMBTU) / (FEFF / 100.)
         FKWH = DUMA / 3413.
         FGOIL = DUMA / 135000.
         FTHCF = DUMA / 1.E6
         GO TO (850, 860, 870) IFURN
  850    CONTINUE
         WRITE(LUW, 9991) FKWH
 9991         FORMAT(/, 5X, 'ELECTRIC FURNACE ENERGY CONSUMPTION',
     &              ' FOR THE PERIOD:', F10.0, ' KWH.')
         GO TO 800
  860    CONTINUE
         WRITE(LUW, 9992) FGOIL
 9992         FORMAT(/, 5X, 'OIL FURNACE ENERGY CONSUMPTION',
     &              ' FOR THE PERIOD:', F10.0, ' GALLONS.')
         GO TO 800
  870    CONTINUE
         WRITE(LUW, 9993) FTHCF
 9993         FORMAT(/, 5X, 'NATURAL GAS FURNACE ENERGY CONSUMPTION',
     &              ' FOR THE PERIOD:', F10.0,
     &              ' THOUSANDS CUBIC FEET.')
         GO TO 800
  890    CONTINUE
         CALL CEQMS(B, BB, EER)
         CLELC = CRMBTU * 1000. / EER
         WRITE(LUW, 9990) CLELC
 9990         FORMAT(/5X, 'CENTRAL AIR CONDITIONER ENERGY CONSUMPTION',
     &              ' FOR THE PERIOD:', F10.0, ' KWH.')
  800 CONTINUE
C
 9903 CONTINUE
 9904 CONTINUE
C
      RETURN
      END
      SUBROUTINE CEQMS(B, BB, EER)
C
C*******************************************************************
C
C  MASTER SUBROUTINE FOR COOLING EQUIPMENT EFFICIENCY CALCULATIONS.
C
C  R. J. RETTBERG  SEPT 1979.
C
C*******************************************************************
C
C  INPUTS:
C     B          = HEAP B VECTOR INPUT.
C     BB         = HEAP BB VECTOR INPUT.
C
```

```
C  OUTPUTS:
C      EER         = AVERAGE ENERGY EFFICIECY RATIO FOR THE CAC
C                    IN BTU / (WATT * HOUR).
C
C*****************************************************************
C
      NAMELIST / DEBUG/ AEERAV
      DIMENSION B(100), BB(40)
C
C
      COMMON /BCACOD/ BEERAC, BEERRE, BHCTOT, BHCS, BHCL,
     &                BHCDRY, BHETOT, BHECP
      COMMON /BCACRD/ BRPEER, BRPHCT, BRPHET, BHEFI, BHEFO
      COMMON /CACDAY/ TEMPRO(48), DELTEM(48)
      COMMON / CONST/ PI
      COMMON / PSYCA/ TD, TW, TDE, TDEW, RH, W, WS, H, HF,
     &                HG, HFG, PWSD, PW, PT,
     &                GNU, RHO
      COMMON/     RW/ ITTY, IREAD, ICHECK
      COMMON/LOOP/ NL1,NL2,LUW
C
      DATA ITTY, IREAD/ 5, 5/
      DATA PI/ 3.14159265/
      DATA PT/ 29.921/
C
C--START EXECUTABLE STMTS.
C
C--SELECT REQUIRED INPUTS FROM B & BB.
C
      TID = BB(4)
      TIN = BB(3)
      TMX = BB(38)
      TMN = BB(40)
      REER = B(93)
      ICHECK = IFIX(B(92))
C
      SUMN = 0.
      SUMD = 0.
C
      CALL TOBIN(TMX, TMN, TID, TIN)
C
      DO 1200 IB = 1, 48
         TODB = TEMPRO(IB)
         TIDB = TEMPRO(IB) - DELTEM(IB)
         IF(ABS(TD - TIDB) .LT. 0.001) GO TO 1185
         TD = TIDB
         RH = 50.
         CALL PSYTW(NIT)
 1185    CONTINUE
         TIWB = TW
         DELT = DELTEM(IB) + 5
         IF(DELT .LE. 0.) GO TO 1200
         CALL CACPMS(TODB, TIDB, TIWB)
         SUMN = DELT + SUMN
         SUMD = DELT / BEERAC + SUMD
 1200 CONTINUE
      IF (SUMD.GT.0.01)GO TO 1250
      TD=TID
      RH=50.
      CALL PSYTW(NIT)
      CALL CACPMS(TMX,TID,TW)
      AEERAV=BEERAC*REER/BRPEER
      GO TO 1300
 1250 CONTINUE
C
      AEERAV = SUMN / SUMD * REER / BRPEER
```

```
 1300 CONTINUE
      EER = AEERAV
C
 9990 CONTINUE
      IF(ICHECK .EQ. 1) WRITE(LUW, DEBUG)
      RETURN
      END
      SUBROUTINE CACPMS(TODB, TIDB, TIWB)
C
C**********************************************************************
C
C  CAC PRODUCT MASTER SUBROUTINE.
C
C  R. J. RETTBERG   20 AUG 1979.
C
C**********************************************************************
C
C  NOTES:
C      1. MODEL OF GE BWB936A CONDENSING UNIT W/ BWV936G AIR
C         HANDLER  @ 1200 CFM.
C
C**********************************************************************
C
      DIMENSION TEMPLM(4)
C
C
      COMMON /BCACOD/ BEERAC, BEERRE, BHCTOT, BHCS, BHCL,
     &                BHCDRY, BHETOT, BHECP
C
C
      COMMON /BCACRD/ BRPEER, BRPHCT, BRPHET, BHEFI, BHEFO
C
      DATA TEMPLM/ 65., 85., 95., 115./
      DATA BHEFI/ 500./
      DATA BHEFO/ 410./
      DATA BRPHCT/ 34000./
      DATA BRPHEC/ 3940./
      DATA IINI/ 1/
C
C--START EXECUTABLE STATEMENTS.
C
      IF(IINI .GT. 1)GO TO 1050
C
      BRPHET = BRPHEC + BHEFI + BHEFO
      BRPEER = BRPHCT / BRPHET
      IINI = 2
C
 1050 CONTINUE
C
      CALL CPPWR(TODB, TIWB, BHECP)
      BHETOT = BHECP + BHEFI + BHEFO
      CALL DRYCAP(TODB, TIDB, BHCDRY)
      CALL TOTCAP(TODB, TIWB, BHCTOT)
C
      IF(TODB .LE. 65.)GO TO 1400
      IF(TODB .GE. 115) GO TO 1450
C
      DO 1080 I = 1, 3
         ISAVE = I
         IF(TODB .LT. TEMPLM(I+1)) GO TO 1081
 1080 CONTINUE
 1081 CONTINUE
C
      GO TO (1165, 1185, 1195) ISAVE
C
 1165 CONTINUE
```

```
C
C--TODB BETWEEN 65 & 85 DEG-F.
C
      CALL SEN65(TIDB, TIWB, BHCS)
      DUMA = BHCS
      CALL SEN85(TIDB, TIWB, BHCS)
      DUMB = BHCS
      DUMC = TODB - 65.
      DUMD = 85. - 65.
      BHCS = DUMA + (DUMC / DUMD) * (DUMB - DUMA)
      GO TO 1480
C
 1185 CONTINUE
C
C--TODB BETWEEN 85 & 95 DEG-F.
C
      CALL SEN85(TIDB, TIWB, BHCS)
      DUMA = BHCS
      CALL SEN95(TIDB, TIWB, BHCS)
      DUMB = BHCS
      DUMC = TODB - 85.
      DUMD = 95. - 85.
      BHCS = DUMA + (DUMC / DUMD) * (DUMB - DUMA)
      GO TO 1480
C
 1195 CONTINUE
C
C--TODB BETWEEN 95 & 115 DEG-F.
C
      CALL SEN95(TIDB, TIWB, BHCS)
      DUMA = BHCS
      CALL SEN115(TIDB, TIWB, BHCS)
      DUMB = BHCS
      DUMC = TODB - 95.
      DUMD = 115. - 95.
      BHCS = DUMA + (DUMC / DUMD) * (DUMB - DUMA)
      GO TO 1480
C
C
 1400 CONTINUE
      CALL SEN65(TIDB, TIWB, BHCS)
      GO TO 1480
 1450 CONTINUE
      CALL SEN115(TIDB, TIWB, BHCS)
C
 1480 CONTINUE
      IF(BHCS .LT. BHCTOT) GO TO 1500
      BHCS = BHCDRY
      BHCL = 0.
      GO TO 1600
C
 1500 CONTINUE
      BHCL = BHCTOT - BHCS
C
 1600 CONTINUE
C
C--DETERMINE ACTUAL & RELATIVE EER-S.
C
      BEERAC = BHCTOT / BHETOT
      BEERRE = BEERAC / BRPEER
C
 9990 CONTINUE
      RETURN
      END
      SUBROUTINE CPPWR(TODB, TIWB, HECP)
C
```

```
C*********************************************************************
C
C  CAC COMPRESSOR INPUT POWER.
C
C  R. J. RETTBERG    16 AUG 1979
C
C*********************************************************************
C
C  INPUTS:
C     TODB       - OUTDOOR DRY-BULB TEMPERATURE IN DEG-F.
C     TIWB       - INDOOR WET-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C     HECP       - CAC COMPRESSOR INPUT POWER IN WATTS.
C
C*********************************************************************
C
      DIMENSION INDXM(10), TEMPLM(7)
C
      DATA  INDXM/ 1, 1, 1, 1, 2, 3, 4, 5, 6, 6/
      DATA TEMPLM/ 65., 85., 90., 95., 100., 105., 115./
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--   F65 ETC. ARE COMPRESSOR INPUT POWERS IN KW FOR 65 DEG-F
C--      OUTDOOR DRY-BULB TEMP.
C
      F65(TIWB)  = 2.9 + (TIWB - 59.) * 0.1 / 4.
      F85(TIWB)  = 3.4 + (TIWB - 59.) * 0.1 / 4.
      F90(TIWB)  = 3.6 + (TIWB - 59.) * 0.1 / 4.
      F95(TIWB)  = 3.7 + (TIWB - 59.) * 0.1 / 4.
      F100(TIWB) = 3.8 + (TIWB - 59.) * 0.133333 / 4.
      F105(TIWB) = 4.0 + (TIWB - 59.) * 0.133333 / 4.
      F115(TIWB) = 4.3 + (TIWB - 59.) * 0.133333 / 4.
C
C--   FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--      COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--      SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--   F SELECTS F65 - F115 BASED IN INDEX I & THE SELECTED
C--      FUNCTION IS EVALUATED AT TIWB.
C
      F(I, TIWB) = FC(I, 1) * F65(TIWB)
     &           + FC(I, 2) * F85(TIWB)
     &           + FC(I, 3) * F90(TIWB)
     &           + FC(I, 4) * F95(TIWB)
     &           + FC(I, 5) * F100(TIWB)
     &           + FC(I, 6) * F105(TIWB)
     &           + FC(I, 7) * F115(TIWB)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TODB .LE. 65.) GO TO 1100
      IF(TODB .GE. 115.) GO TO 1200
C
      IDUMA = IFIX((TODB - 60.) / 5.)
      ILOW = INDXM(IDUMA)
      TLOW = TEMPLM(ILOW)
      THIGH = TEMPLM(ILOW + 1)
      DUMA = F(ILOW, TIWB)
      DUMB = F(ILOW + 1, TIWB)
      DUMC = DUMB - DUMA
      DUMD = TODB - TLOW
      DUME = THIGH - TLOW
```

```
      HECP  = DUMA + (DUMD / DUME) * DUMC
      GO TO 9990
C
C
 1100 CONTINUE
      HECP = F(1, TIWB)
      GO TO 9990
C
 1200 CONTINUE
      HECP = F(7, TIWB)
 9990 CONTINUE
      HECP = 1000. * HECP
      RETURN
      END
      SUBROUTINE DRYCAP(TODB, TIDB, HCDRY)
C
C*****************************************************************
C
C  CAC DRY COIL COOLING.
C
C  R. J. RETTBERG    16 AUG 1979
C
C*****************************************************************
C
C  INPUTS:
C     TIDB       - INDOOR THERMOSTAT SETTING IN DEG-F.
C     TODB       - OUTDOOR DRY-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C     HCDRY        - CAC DRY COIL COOLING CAPACITY IN BTU/H.
C
C*****************************************************************
C
      DIMENSION INDXM(10), TEMPLM(7)
C
      DATA  INDXM/ 1, 1, 1, 1, 2, 3, 4, 5, 6, 6/
      DATA TEMPLM/ 65., 85., 90., 95., 100., 105., 115./
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--    F65 ETC. ARE DRY-COIL CAPACITIES IN KBTU/H FOR 65 DEG-F
C--       OUTDOOR DRY-BULB TEMP.
C
      F65(TIDB)   = 33.6 + (TIDB - 80.) * 0.129
      F85(TIDB)   = 32.3 + (TIDB - 80.) * 0.254
      F90(TIDB)   = 31.8 + (TIDB - 80.) * 0.279
      F95(TIDB)   = 31.1 + (TIDB - 80.) * 0.283
      F100(TIDB)  = 30.4 + (TIDB - 80.) * 0.317
      F105(TIDB)  = 29.6 + (TIDB - 80.) * 0.342
      F115(TIDB)  = 27.6 + (TIDB - 80.) * 0.350
C
C--    FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--       COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--       SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--    F SELECTS F65 - F115 BASED IN INDEX I & THE SELECTED
C--       FUNCTION IS EVALUATED AT TIDB.
C
      F(I, TIDB) = FC(I, 1) * F65(TIDB)
     &            + FC(I, 2) * F85(TIDB)
     &            + FC(I, 3) * F90(TIDB)
     &            + FC(I, 4) * F95(TIDB)
     &            + FC(I, 5) * F100(TIDB)
     &            + FC(I, 6) * F105(TIDB)
```

```
     8              + FC(1, 7) * F115(TIDB)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TODB .LE. 65.) GO TO 1100
      IF(TODB .GE. 115.) GO TO 1200
C
      IDUMA = IFIX((TODB - 60.) / 5.)
      ILOW = INDXM(IDUMA)
      TLOW = TEMPLM(ILOW)
      THIGH = TEMPLM(ILOW + 1)
      DUMA = F(ILOW, TIDB)
      DUMB = F(ILOW + 1, TIDB)
      DUMC = DUMB - DUMA
      DUMD = TODB - TLOW
      DUME = THIGH - TLOW
      HCDRY  = DUMA + (DUMD / DUME) * DUMC
      GO TO 9990
C
 1100 CONTINUE
      HCDRY = F(1, TIDB)
      GO TO 9990
C
 1200 CONTINUE
      HCDRY = F(7, TIDB)
 9990 CONTINUE
      HCDRY = 1000. * HCDRY
      RETURN
      END
      SUBROUTINE PSYALL
C     THIS SUBROUTINE CALCULATES ALL PSYC PARAMETERS OF INTEREST
C     FROM DRY BULB TEMP(TD),AND WET BULB (TW) TEMP (DEG-F), AND
C     TOTAL PRESSURE (IN-HG)
C
C     ROUTINE APPEARS ACCURATE TO 1-PERCENT OR BETTER IN THE
C     RANGE OF TDB = 10,110 DEG-F
C
C
      COMMON / PSYCA/ TD, TW, TDE, TDEW, RH, W, WS, H, HF,
     8                HG, HFC, PWSD, PW, PT,
     8                GNU, RHO
C
C
C     BEGIN GENERAL EQUATIONS
      CPWS(A)=0.0247376-3.05625E-04*A+1.11272E-04*A**2
     1      -2.18039E-06*A**3+3.48030E-08*A**4
     2      -2.02293E-10*A**5+5.65645E-13*A**6
      CPW(A,B)=(A*B)/(0.62198+B)
      CW(A,B)=0.62198*(A/(B-A))
      CTDWA(A)=79.047+30.5790*A+1.8893*A**2
      CTDWB(A)=71.98+24.873*A+0.8927*A**2
C     END OF EQUATIONS, GENERAL
      PWSD=CPWS(TD)*29.921/14.6960
      PWSW=CPWS(TW)*29.921/14.6960
      IF(TW-32.)15,15,20
   15 HFG=1220.29-5.26779E-02*TW
      HF=-159.179+0.491976*TW
      GO TO 40
   20 HFG=1093.27-0.565495*TW
      IF(TW-42.)25,25,30
   25 HF=-32.1518+1.0048*TW
      GO TO 40
   30 HF=-31.9412+1.00027*TW
   40 HG=1061.27+0.435566*TD
      WS=CW(PWSW,PT)
      W=AMAX1(1.E-08,((WS*HFG)-0.24*(TD-TW))/(HG-HF))
```

```
      PW=CPW(PT,W)
      RH=PW/PWSD*100.
      XPW=ALOG(PW)
      IF(TD.LT.32.)TDEW=CTDWB(XPW)
      IF(TD.GE.32.)TDEW=CTDWA(XPW)
      TDEP=TD-TW
      GNU=53.352*(TD+459.67)*(1+1.6078*W)/PT/70.7262
      RHO=1./GNU
      H=0.24*TD+W*HC
      RETURN
      END
      SUBROUTINE PSYTW(NIT)
C     THIS SUBROUTINE CALCULATES THE WET BULB TEMP FOR A GIVEN DRY BULB
C     TEMP, RH, AND TOTAL PRESSURE(IN-HG)
      DIMENSION ATW(3),AWSW(3),AW(3),APWSW(3),WTEST(3),ERR(3)
C
C
      COMMON / PSYCA/ TD, TW, TDE, TDEW, RH, W, WS, H, HF,
     &                HC, HFC, PWSD, PW, PT,
     &                GNU, RHO
C
C
C     START GEN EQUATIONS
      CPWS(A)=0.0247376-3.05625E-04*A+1.11272E-04*A**2
     1       -2.18039E-06*A**3+3.48030E-08*A**4
     2       -2.02293E-10*A**5+5.65645E-13*A**6
      WCAL(A,B)=0.62198*(A/(B-A))
      WIT(A,B,C)=(((1093.-0.556*A)*B)-0.240*(C-A))/(1093.+0.444*C-A)
C     END GENERAL EQUATIONS
      PWSD=CPWS(TD)*29.921/14.6960
      PWD=PWSD*RH/100.
      WACT=WCAL(PWD,PT)
      NIT=0
      K=0
      IF(TD.LT.50)CRI=1.E-07
      IF(TD.GE.50)CRI=1.E-06
      ATW(1)=TD-0.2
      ATW(2)=TD-10.
      ATW(3)=TD-30.
      IF(TD.GT.80)ATW(2)=ATW(2)-20
      IF(TD.GT.80)ATW(3)=ATW(3)-20.
      IF(TD.LT.10)ATW(2)=ATW(2)+7.5
      IF(TD.LT.10)ATW(3)=ATW(3)+25.
    1 NIT=NIT+1
      IF(NIT.GT.15)GO TO 35
      DO 5 I=1,3
      TW=AMIN1((TD-.0001),ATW(I))
      CALL PSYALL
      WTEST(I)=W
      ERR(I)=WACT-W
    5 IF(ABS(ERR(I)).LT.CRI)K=I
      IF(K.GT.0)GO TO 30
      IF(ERR(2))20,20,25
   25 ATW(3)=ATW(2)
      ATW(2)=ATW(1)+ABS(ERR(1))/(ABS(ERR(2))+ABS(ERR(1)))
     1       *(ATW(3)-ATW(1))
      GO TO 1
   20 ATW(1)=ATW(2)
      ATW(2)=ATW(1)+ABS(ERR(2))/(ABS(ERR(2))+ABS(ERR(3)))
     1       *(ATW(3)-ATW(1))
      GO TO 1
   30 TW=ATW(K)
      RETURN
   35 TW=99.99
      NIT=NIT-1
      RETURN
```

```
      END
      SUBROUTINE SEN65(TIDB, TIWB, HCS)
C
C*****************************************************************
C
C  CAC SENSIBLE COOLING FOR 65 DEG-F TODB.
C
C  R. J. RETTBERG   16 AUG 1979
C
C*****************************************************************
C
C  INPUTS:
C     TIDB       - INDOOR THERMOSTAT SETTING IN DEG-F.
C     TIWB       - INDOOR WET-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C     HCS        - CAC SENSIBLE COOLING CAPACITY IN BTU/H.
C
C*****************************************************************
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--   F55 ETC. ARE SESIBLE CAPACITY IN KBTU/H FOR 55 DEG-F WET-BULB TEMP.
C
      F55(TIDB) = 32.7 + (TIDB - 72.) * 2.0 / 2.
      F59(TIDB) = 27.4 + (TIDB - 72.) * 1.9 / 2.
      F63(TIDB) = 22.4 + (TIDB - 72.) * 1.8 / 2.
      F67(TIDB) = 17.7 + (TIDB - 72.) * 1.7 / 2.
      F71(TIDB) = 13.5 + (TIDB - 72.) * 1.6 / 2.
C
C--   FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--      COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--      SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--   F SELECTS F55 - F71 BASED IN INDEX I & THE SELECTED
C--      FUNCTION IS EVALUATED AT TIDB.
C
      F(I, TIDB) = FC(I, 1) * F55(TIDB)
     &            + FC(I, 2) * F59(TIDB)
     &            + FC(I, 3) * F63(TIDB)
     &            + FC(I, 4) * F67(TIDB)
     &            + FC(I, 5) * F71(TIDB)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TIWB .LE. 55.) GO TO 1100
      IF(TIWB .GE. 71.) GO TO 1200
C
      ILOW = IFIX((TIWB - 51.) / 4.)
      DUMA = F(ILOW, TIDB)
      DUMB = F(ILOW + 1, TIDB)
      DUMC = DUMB - DUMA
      DELX = TIWB - (51. + 4. * ILOW)
      HCS  = DUMA + (DELX / 4.) * DUMC
      GO TO 9990
C
 1100 CONTINUE
      HCS = F(1, TIDB)
      GO TO 9990
C
 1200 CONTINUE
      HCS = F(5, TIDB)
 9990 CONTINUE
      HCS = 1000. * HCS
```

```
      RETURN
      END
      SUBROUTINE SEN85(TIDB, TIWB, HCS)
C
C*****************************************************************
C
C  CAC SENSIBLE COOLING FOR 85 DEG-F TODB.
C
C  R. J. RETTBERG    16 AUG 1979
C
C*****************************************************************
C
C  INPUTS:
C     TIDB       - INDOOR THERMOSTAT SETTING IN DEG-F.
C     TIWB       - INDOOR WET-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C     HCS        - CAC SENSIBLE COOLING CAPACITY IN BTU/H.
C
C*****************************************************************
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--   F55 ETC. ARE SESIBLE CAPACITY IN KBTU/H FOR 55 DEG-F WET-BULB TEMP.
C
      F55(TIDB) = 31.9 + (TIDB - 72.) * 2.2 / 2.
      F59(TIDB) = 26.6 + (TIDB - 72.) * 2.1 / 2.
      F63(TIDB) = 21.6 + (TIDB - 72.) * 2.0 / 2.
      F67(TIDB) = 16.9 + (TIDB - 72.) * 1.9 / 2.
      F71(TIDB) = 12.7 + (TIDB - 72.) * 1.8 / 2.
C
C--   FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--      COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--      SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--   F SELECTS F55 - F71 BASED IN INDEX I & THE SELECTED
C--      FUNCTION IS EVALUATED AT TIDB.
C
      F(I, TIDB) = FC(I, 1) * F55(TIDB)
     &           + FC(I, 2) * F59(TIDB)
     &           + FC(I, 3) * F63(TIDB)
     &           + FC(I, 4) * F67(TIDB)
     &           + FC(I, 5) * F71(TIDB)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TIWB .LE. 55.) GO TO 1100
      IF(TIWB .GE. 71.) GO TO 1200
C
      ILOW = IFIX((TIWB - 51.) / 4.)
      DUMA = F(ILOW, TIDB)
      DUMB = F(ILOW + 1, TIDB)
      DUMC = DUMB - DUMA
      DELX = TIWB - (51. + 4. * ILOW)
      HCS  = DUMA + (DELX / 4.) * DUMC
      GO TO 9990
C
 1100 CONTINUE
      HCS = F(1, TIDB)
      GO TO 9990
C
 1200 CONTINUE
      HCS = F(5, TIDB)
 9990 CONTINUE
```

```
      HCS = 1000. * HCS
      RETURN
      END
      SUBROUTINE SEN95(TIDB, TIWB, HCS)
C
C*****************************************************************
C
C  CAC SENSIBLE COOLING FOR 95 DEG-F TODB.
C
C  R. J. RETTBERG    16 AUG 1979
C
C*****************************************************************
C
C  INPUTS:
C     TIDB        - INDOOR THERMOSTAT SETTING IN DEG-F.
C     TIWB        - INDOOR WET-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C     HCS         - CAC SENSIBLE COOLING CAPACITY IN BTU/H.
C
C*****************************************************************
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--   F55 ETC. ARE SESIBLE CAPACITY IN KBTU/H FOR 55 DEG-F WET-BULB TEMP.
C
      F55(TIDB) = 27.5 + (TIDB - 72.) * 2.3 / 2.
      F59(TIDB) = 26.2 + (TIDB - 72.) * 2.2 / 2.
      F63(TIDB) = 21.2 + (TIDB - 72.) * 2.1 / 2.
      F67(TIDB) = 16.5 + (TIDB - 72.) * 2.0 / 2.
      F71(TIDB) = 12.3 + (TIDB - 72.) * 1.9 / 2.
C
C--   FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--      COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--      SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--   F SELECTS F55 - F71 BASED IN INDEX I & THE SELECTED
C--      FUNCTION IS EVALUATED AT TIDB.
C
      F(I, TIDB) = FC(I, 1) * F55(TIDB)
     &           + FC(I, 2) * F59(TIDB)
     &           + FC(I, 3) * F63(TIDB)
     &           + FC(I, 4) * F67(TIDB)
     &           + FC(I, 5) * F71(TIDB)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TIWB .LE. 55.) GO TO 1100
      IF(TIWB .GE. 71.) GO TO 1200
C
      ILOW = IFIX((TIWB - 51.) / 4.)
      DUMA = F(ILOW, TIDB)
      DUMB = F(ILOW + 1, TIDB)
      DUMC = DUMB - DUMA
      DELX = TIWB - (51. + 4. * ILOW)
      HCS  = DUMA + (DELX / 4.) * DUMC
      GO TO 9990
C
 1100 CONTINUE
      HCS = F(1, TIDB)
      GO TO 9990
C
 1200 CONTINUE
      HCS = F(5, TIDB)
```

```
 9990 CONTINUE
      HCS = 1000. * HCS
      RETURN
      END
      SUBROUTINE SEN115(TIDB, TIWB, HCS)
C
C*****************************************************************
C
C  CAC SENSIBLE COOLING FOR 115 DEG-F TODB.
C
C  R. J. RETTBERG    16 AUG 1979
C
C*****************************************************************
C
C  INPUTS:
C     TIDB        - INDOOR THERMOSTAT SETTING IN DEG-F.
C     TIWB        - INDOOR WET-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C     HCS         - CAC SENSIBLE COOLING CAPACITY IN BTU/H.
C
C*****************************************************************
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--   F55 ETC. ARE SESIBLE CAPACITY IN KBTU/H FOR 55 DEG-F WET-BULB TEMP.
C
      F55(TIDB) = 29.0 + (TIDB - 72.) * 2.4 / 2.
      F59(TIDB) = 24.3 + (TIDB - 72.) * 2.3 / 2.
      F63(TIDB) = 19.7 + (TIDB - 72.) * 2.2 / 2.
      F67(TIDB) = 15.2 + (TIDB - 72.) * 2.1 / 2.
      F71(TIDB) = 10.9 + (TIDB - 72.) * 2.0 / 2.
C
C--   FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--      COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--      SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--   F SELECTS F55 - F71 BASED IN INDEX I & THE SELECTED
C--      FUNCTION IS EVALUATED AT TIDB.
C
      F(I, TIDB) = FC(I, 1) * F55(TIDB)
     &            + FC(I, 2) * F59(TIDB)
     &            + FC(I, 3) * F63(TIDB)
     &            + FC(I, 4) * F67(TIDB)
     &            + FC(I, 5) * F71(TIDB)
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TIWB .LE. 55.) GO TO 1100
      IF(TIWB .GE. 71.) GO TO 1200
C
      ILOW = IFIX((TIWB - 51.) / 4.)
      DUMA = F(ILOW, TIDB)
      DUMB = F(ILOW + 1, TIDB)
      DUMC = DUMB - DUMA
      DELX = TIWB - (51. + 4. * ILOW)
      HCS  = DUMA + (DELX / 4.) * DUMC
      GO TO 9990
C
 1100 CONTINUE
      HCS = F(1, TIDB)
      GO TO 9990
C
 1200 CONTINUE
```

```
      HCS = F(5, TIDB)
 9990 CONTINUE
      HCS = 1000. * HCS
      RETURN
      END
      SUBROUTINE TOBIN(TMX, TMN, TID, TIN)
C
C*************************************************************************
C
C  DAILY BINNING OF OUTDOOR DRY-BULB TEMPERATURES & RESIDENCE
C     DELTA-TEMPERATURES.
C
C  R. J. RETTBERG  26 AUG 1979.
C
C*************************************************************************
C
      NAMELIST / DEBUG/ IFCT, CA, CB, TCREF, TEMPRO, DELTEM
C
      DIMENSION IFCT(48), CA(3), CB(3), TCREF(3)
C
C
      COMMON /CACDAY/ TEMPRO(48), DELTEM(48)
C
C
      COMMON / CONST/ PI
C
C
      COMMON/    RW/ ITTY, IREAD, ICHECK
      COMMON/LOOP/NL1,NL2,LUW
C
C
      DATA IFCT/ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
     &           1, 1, 1, 1, 1, 1, 1, 1,
     &           2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
     &           2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
     &           2, 2, 2, 2, 2, 2, 2, 2,
     &           3, 3/
C
C--START EXECUTABLE STATEMENTS.
C
C--SET THE CONSTANTS IN THE COSINE ** 2 EQUATIONS THAT FIT
C--    THE WEATHER DATA.
C
      AN = 2.
      CA(1) = TMN
      CB(1) = TMX - TMN
      TCREF(1) = 15.
C
      CA(2) = TMN
      CB(2) = (TMX - TMN)
      TCREF(2) = 15.
C
      CA(3) = TMN
      CB(3) = TMX - TMN
      TCREF(3) = 39.
C
C--FILL THE /CACDAY/ TEMPERATURE VECTORS.
C
      DO 1200 I = 1, 48
         IFX = IFCT(I)
         DUMA = 5.75 + I * 0.5
         DUMB = 20.
         IF(IFX .EQ. 2) DUMB = 28.
         DUMC = (DUMA - TCREF(IFX)) / DUMB
         TODB = CA(IFX) + CB(IFX) *
     &          ((COS(PI * DUMC)) ** AN)
```

```
         TEMPRO(I) = TODB
 1200 CONTINUE
C
      DO 1300 I = 1, 48
         TIDB = TID
         IF(I .GT. 24) TIDB = TIN
         DELTEM(I) = TEMPRO(I) - TIDB
 1300 CONTINUE
C
 9990 CONTINUE
      IF(ICHECK .EQ. 1) WRITE(LUW, DEBUG)
      RETURN
      END
      SUBROUTINE TOTCAP(TODB, TIWB, HCTOT)
C
C******************************************************************
C
C  CAC TOTAL COOLING CAPACITY.
C
C  R. J. RETTBERG    16 AUG 1979
C
C******************************************************************
C
C   INPUTS:
C      TODB       - OUTDOOR DRY-BULB TEMPERATURE IN DEG-F.
C      TIWB       - INDOOR WET-BULB TEMP IN DEG-F.
C
C  OUTPUTS:
C      HCTOT      - CAC TOTAL COOLING CAPACITY IN BTU/H.
C
C******************************************************************
C
      DIMENSION INDXM(10), TEMPLM(7)
C
      DATA  INDXM/ 1, 1, 1, 1, 2, 3, 4, 5, 6, 6/
      DATA TEMPLM/ 65., 85., 90., 95., 100., 105., 115./
C
C--DEFINE SUBROUTINE FUNCTIONS.
C
C--   F65 ETC. ARE TOTAL CAPACITIES IN KBTU/H FOR 65 DEG-F
C--      OUTDOOR DRY-BULB TEMP.
C
      F65(TIWB)   = 32.4 + (TIWB - 59.) * 1.5 / 4.
      F85(TIWB)   = 31.4 + (TIWB - 59.) * 1.7 / 4.
      F90(TIWB)   = 30.7 + (TIWB - 59.) * 1.8 / 4.
      F95(TIWB)   = 29.8 + (TIWB - 59.) * 1.9 / 4.
      F100(TIWB) = 28.8 + (TIWB - 59.) * 1.96666 / 4.
      F105(TIWB) = 27.6 + (TIWB - 59.) * 2.1 / 4.
      F115(TIWB) = 25.0 + (TIWB - 59.) * 2.23333 / 4.
C
C--   FC IS A COEFFICIENT SELECTION FUNCTION.  IT SETS ALL
C--      COEFFICIENTS EXCEPT THE I = IX ONE TO ZERO.  THE
C--      SELECTED COEFFICIENT IS SET = 1.
C
      FC(I, IX) = MAX0(0, I - IX + 1) * MAX0(0, IX - I + 1)
C
C--   F SELECTS F65 - F115 BASED IN INDEX I 8 THE SELECTED
C--      FUNCTION IS EVALUATED AT TIWB.
C
      F(I, TIWB) = FC(I, 1) * F65(TIWB)
     8            + FC(I, 2) * F85(TIWB)
     8            + FC(I, 3) * F90(TIWB)
     8            + FC(I, 4) * F95(TIWB)
     8            + FC(I, 5) * F100(TIWB)
     8            + FC(I, 6) * F105(TIWB)
     8            + FC(I, 7) * F115(TIWB)
```

```
C
C--START EXECUTABLE STATEMENTS.
C
      IF(TODB .LE. 65.) GO TO 1100
      IF(TODB .GE. 115.) GO TO 1200
C
      IDUMA = IFIX((TODB - 60.) / 5.)
      ILOW = INDXM(IDUMA)
      TLOW = TEMPLM(ILOW)
      THIGH = TEMPLM(ILOW + 1)
      DUMA = F(ILOW, TIWB)
      DUMB = F(ILOW + 1, TIWB)
      DUMC = DUMB - DUMA
      DUMD = TODB - TLOW
      DUME = THIGH - TLOW
      HCTOT  = DUMA + (DUMD / DUME) * DUMC
      GO TO 9990
C
C
 1100 CONTINUE
      HCTOT = F(1, TIWB)
      GO TO 9990
C
 1200 CONTINUE
      HCTOT = F(7, TIWB)
 9990 CONTINUE
      HCTOT = 1000. * HCTOT
      RETURN
      END
```

APPENDIX C

NORM VALIDATION FIELD TEST PLAN

AD-A081 057 OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE (--ETC F/G 13/1
FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
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SAI-176-79-769-LJ

NORM VALIDATION FIELD TEST PLAN (TASK 5 OF UTILITY NORM ANALYSIS OF NAVAL HOUSING ENERGY CONSERVATION PROGRAM)

June 1979

by

L.B. Gratt

R.K. McCord

Prepared for:

Department of the Navy
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, Virginia 22322

Under Contract No.
N00-023-78-C1019

26 June 1979

Robert Sykes
Naval Facilities Engineering Command
Department of the Navy
200 Stovall Street
Alexandria, Virginia 22332

Subject: Review of Field Test Plan and Draft Norm Pamphlet

Dear Mr. Sykes:

Enclosed please find four (4) copies of the Norm Evaluation Field Test Plan and four (4) draft copies of the Norm Pamphlet for your review. The final version of the Norm Pamphlet will be in color. Your comments will be appreciated.

Sincerely,

Richard K. McCord

Richard K. McCord
Task Leader for Field
Test Activity

RKM:scg
encl.

Science Applications, Inc. 1200 Prospect St., P.O. Box 2351, La Jolla, CA 92038, (714) 454-3811

Other SAI Offices: Albuquerque, Ann Arbor, Arlington, Atlanta, Boston, Chicago, Huntsville, Los Angeles, McLean, Palo Alto, San Diego, Sunnyvale, and Tucson.

1. INTRODUCTION

The field test program has three principal functions:

a) preparation of an explanatory "norm" pamphlet for occupants of military housing,

b) acquisition of residence data and two months (July 13 through September 13) of metered and resident - estimated energy consumption data for selected dwellings at four particular military bases,

c) utilization of these data for the purpose of validating the "norm" calculation procedure.

The preparation of a "norm" pamphlet is independent of the latter two functions of this program, but it will be used and evaluated in conjunction with the acquisition of the residence data and the energy consumption data. The principal outputs of the field test task are the "norm" pamphlet, a comprehensive energy requirements/consumption data base for the participating residences, and a finalized and validated "norm" calculation procedure.

The field test task (Task 5) has been divided into five subtasks:

5.a Norm Pamphlet
5.b Field Test Program Plan
5.c Data Acquisition
5.d Data Evaluation
5.e Norm Evaluation and Finalization

The sections which follow divide these subtasks into groups in such a way as to explain the field test program plan and the implementation procedure. The field test task organization and scheduling are presented in Section 11.

2. NORM PAMPHLET

The "norm" pamphlet is a brief (8-12 page), picture-oriented brochure which will inform military housing occupants as to the use of the energy consumption "norm". A draft version of the pamphlet will be used in the field test activity as a source of background information for the participants. The target audience of the final version of this pamphlet is all military housing occupants to whom the "norm" will be applicable. In arriving at the final version of the pamphlet, feedback regarding the draft version will be solicited from the field test participants.

The following is a rough outline of the main points of the pamphlet:

1. Emphasize concern over energy in U.S.
2. Point out Congressional action which mandated new energy conservation efforts in the military.
3. Introduce the idea of a "norm."
4. Introduce the "norm" which will be used via its components, i.e., what goes into the "norm."
5. Show how it will affect personnel in military housing.
6. Give tips on energy conservation relevant to the military housing audience.

The details of the "norm" will not be presented in the pamphlet because the pamphlet is intended to be simple and concise. Instead, the fairness of a "norm" concept and of this particular implementation of a "norm" will be emphasized. It will be made clear that allowances will be made for those who live in more severe climates, those who have larger families, etc. That is, the "norm" will reflect a family's needs instead of being a rationing plan, and these needs will be tailored to each individual family, in specific weather conditions, in a particular residence with specific integral and removable appliances.

The pamphlet will describe the implementation of the "norm" program. It will be emphasized that, if a family does not overconsume energy, the "norm" will have no effect on them whatsoever.

The pamphlet will be circulated among the SAI staff working on Tasks A, B and C for comments. A revised pamphlet will be presented to the Navy for comment and revision before the field activity begins. Prior to the release of the pamphlet, it will be reviewed from a psychological standpoint to ensure that it is appropriate for the target audience.

3. SITE AND PARTICIPANT SELECTION

The four sites which have been selected for the field test activity and the SAI contacts at these sites are:

1. Fort Eustis, Va.
   (Mr. Blaney Hill)
2. PWC Great Lakes, IL.
   (Mr. A.L. Bradley, Ms. Pam Hughes)
3. Port Hueneme, CA.
   (Ms. Eileen Greene, Mr. Bill Robinson)
4. Fort Hood, TX.
   (Mr. Mel Davis, Ms. Shannon Anderson)

The first three of these sites participate in the DoD Pilot Metering Program, while Fort Hood is included in the CERL Fixed Facility Energy Consumption Investigation.

The individual households participating in the field test will be selected so as to provide appropriate diversity in building and occupant characteristics. The major factors which will be considered include:

(a) instrumentation of both the incoming electricity and incoming fossil fuel lines,

(b) size and building characteristics (orientation, dimensions, etc.),

(c) types of heating and cooling appliances, and

(d) number and ages of occupants.

The selections will be made on the basis of which of the above information is available prior to the start of the field test.

From master lists documenting the information available from (a)-(d) above for each unit participating in the Pilot Metering Program or Fixed Facility Energy Consumption Investiga-

tion, a list will be drawn up to form the set of preferred candidates for field test participants. SAI staff members will contact candidates during the week prior to the start of the field test activity in order to obtain participation commitments and begin acquiring data. This initial data acquisition is explained in detail in Section 6.

4. INSTRUMENTATION

Each participant household will be provided with a wall thermometer for a once-daily temperature recording in the largest room of the residence. The additional instrumentation utilized in the residences will depend on whether the dwelling was included in the DoD Pilot Metering Program or in the CERL Fixed Facility Energy Consumption Investigation. In either case, the metering instrumentation is already in place.

Each dwelling selected from the Pilot Metering Program has a meter for electricity consumption and, where relevant, a meter for oil or natural gas consumption. The dwellings selected from the CERL Fixed Facility Energy Consumption Investigation have the same instrumentation with the additional capacity to record hourly energy consumption data for the building.

Weather data is already being collected at Fort Hood under the Fixed Facility Energy Consumption Investigation, and weather data from the weather station at Point Mugu will be used for Port Hueneme. The dry bulb temperature is taken at Fort Eustis and Great Lakes under the Pilot Metering Program, but no other data is collected. Consequently, SAI is arranging for the leasing of equipment at these two bases to measure and record wet bulb temperature, wind speed and direction and solar radiation.

5. DATA REQUIREMENTS

The data required from the field test activity falls into five major categories:

1. site weather data,
2. building characteristics,
3. appliance data,
4. human factors data, and
5. energy consumption data.

The weather data will be collected on a site-by-site basis, while the remaining four categories pertain to the individual households participating in the field test.

5.1 SITE WEATHER DATA

Four weather-related quantities are required in the heating and cooling requirements portion of the "norm" evaluation:

a. wind velocity and direction,

b. dry bulb temperature,

c. wet bulb temperature, and

d. insolation.

Wherever possible, these quantities will be used on the basis of their hourly values. If that is infeasible, the daily maximum, minimum and average values will be employed in determining "norm" values.

5.2 BUILDING CHARACTERISTICS

These data again relate to the heating and cooling requirements portion of the "norm" in that they help determine what effect the weather factors have on the building's space conditioning loads. The information which will be used to assess the building loads is:

(a) the building's construction materials,

(b) building orientation (used with respect to wind direction and insolation factors),

(c) building configuration and dimensions, and

(d) insulation.

5.3 APPLIANCE DATA

In order to assess the energy consumption of appliances, it is necessary to know what types of appliances are in use. This is feasible only for the major household appliances. Those which will be considered separately in the "norm" calculations will be assessed according to nameplate information:

(a) furnace
(b) heat pump
(c) air conditioner (central or room)
(d) humidifier
(e) dehumidifier
(f) water heater
(g) refrigerator/freezer
(h) dishwasher
(i) clothes washer
(j) clothes dryer
(k) range
(l) oven
(m) television set

In addition, a measure of the building lighting will be made. This will consist of collecting data on the wattage of the various light bulbs and each light fixture's usage, general

(e.g., room lights) or special (e.g., kitchen range light).

To supplement the water heater information, the cold water supply temperature will also be required.

5.4 HUMAN FACTORS

The human characteristics of a household will clearly influence the total energy consumption in a dwelling. Several of the most basic of these characteristics will be incorporated into the "norm" calculations:

(a) number and age of occupants

(b) spouse employment status

(c) hours of dwelling vacancy

Additional human factors data identified in Task 3 will be collected for use in the evaluation of the "norm" calculation procedure.

5.5 ENERGY CONSUMPTION

Finally, it will be necessary to record actual and reported energy consumption data:

(a) electrical consumption (meter)

(b) oil or natural gas consumption (meter)

(c) daily indoor temperature reading (taken at 3 p.m. in the dwelling's largest room)

(d) appliance usage data (participant logging)

(e) shower/bath usage data (participant logging)

The usage data will be "close as possible" estimates of the daily usage patterns of the household in order to correlate with energy consumption data.

6. PARTICIPANT ORIENTATION AND INITIAL DATA ACQUISITION

One SAI staff member will be assigned to each site, and this person will be responsible for participant orientation and initial data acquisition. The SAI staff member will contact prospective field test participants through personal visits during the week before the field test activity begins. These people will have been informed by the Base Housing Office that an SAI representative may be soliciting their participation. The SAI staff member will briefly describe SAI's purpose in conducting the field test and the participant's role and remuneration in this activity. For those residents who agree to participate, an in-depth interview will then be conducted or a time for such a meeting will be arranged.

The format of this meeting will be as follows: The SAI staff member will

1) give a more complete description of the purpose and procedure of the field test and the participants' role,

2) interview participants in order to ascertain the relevant human factors data:

   a) number of occupants
   b) spouse employment status
   c) normal hours of dwelling vacancy
   d) other items identified in Task 3

3) collect appliance nameplate data and lighting data in accordance with the list of appliances in Section 5,

4) explain the use of the participant log sheets,

5) describe the payment for participation (a $50 check from SAI once a month),

6) inform the participants of the procedure for answering questions (see below),

7) hand out the log sheets which will be required until the time of the next SAI visit, and discuss their use,

8) demonstrate the meter reading and logging technique to the participants on the participants' own meter(s),

9) hand out and discuss the "norm" pamphlet along with a special one-page introduction to the field-test activity. (See Figure 1 for a preliminary version of the introductory page.) The purpose of the introductory page is to summarize the goals of the field test and serve as a procedural reference for the participants throughout the field test activity,

10) solicit and answer any final questions, and remind the participants of the time of the next SAI visit.

Before leaving the base, the SAI staff member will contact the participants once more in order to answer any questions which may have arisen. Further details of the logging process are described in Section 8.

Each participant will be asked to sign an agreement which explains the participant's responsibilities and the consideration provided by SAI for these services. (See Figure 2.)

The procedure for answering participants' questions will be as follows:

1) The participant will be given the number of the base housing office on the introductory page, and the participant should call this number and leave a message for the SAI staff member.

2) During the initial visit to the site, the SAI staff member will check with the base housing office periodically for messages.

3) After the initial visit, an SAI staff member will check with the base housing office once weekly for messages. The questions will be answered at the time of an SAI staff member's visit to the site for meter reading and collection (distribution) of old (new) log sheets or through telephone contact with the participant.

7. PARTICIPANT DATA LOGGING

The field test participants will be asked to log the following data for each day of the field test:

- (a) number of uses of the dishwasher on that day (if applicable)
- (b) number of uses of the clothes washer on that day (if applicable)
- (c) number of uses of the clothes dryer on that day (if applicable)
- (d) approximate total usage time of the kitchen range on that day (range is ON if one [or more] burner[s] is on)
- (e) approximate total usage time of the kitchen oven on that day
- (f) approximate total usage time of the television on that day
- (g) total numbers of showers/baths on that day
- (h) temperature reading in the dwelling's largest room at 6 p.m.
- (i) approximate number of hours that the dwelling was vacant on that day.

In addition, the participants will be asked to record the readings on their electricity and natural gas (or fuel oil) meters daily at 6 p.m. during the first two weeks of the field test activity. Participants will only be asked to record the meter hand positions.

Preliminary versions of the participant log sheets are presented in Figure 3 and Figure 4. For those participants with digital meters, different meter log sheets will be provided.

8. DATA ACQUISITION AND HANDLING

The data acquisition task is the implementation of the field test program and consists of the gathering of all the information required to calculate the "norm." The data will be acquired from the following sources:

1.	Site weather data -	site weather station or nearby weather station;
2.	Building characteristics -	part of the CERL data base, or can be obtained in the form of "as-built" plans from the Base Housing Officer;
3.	Appliance data -	meetings between SAI staff members and individual field test participants;
4.	Human factors data -	individual meetings between SAI staff members and field test participants;
5.	Energy consumption data -	participant log sheets and visits by SAI staff members

Weather records during the field test will be acquired through arrangements with the base weather station or through the use of leased weather data recording instruments. Records for the first month of the test will be collected immediately after the first month's testing is completed with the remaining month's records being collected at the termination of the field test.

The data on building characteristics for Fort Hood will be in the form of "as-built" plans obtained from the Base Housing Officer. Building plans for the other three sites will be obtained from CERL records.

As described in Section 6, the appliance nameplate data will be obtained during the initial meetings with the individual field test participants. The SAI staff member will inspect each major appliance and record the nameplate data. The SAI staff

member will record the wattage and type of use (general or special) of each light bulb in the dwelling. At this time, the SAI staff member will also interview the participants in order to ascertain the relevant human factors data.

The major component of the data acquisition task is the gathering of energy consumption data. This effort will gather both metered and estimated energy consumption data.

The metered consumption data will be gathered through weekly (or bi-weekly) electrical and natural gas (or fuel oil) meter readings conducted by SAI staff members at Fort Eustis, Great Lakes and Port Hueneme. The meter readings recorded during the Fixed Facility Energy Consumption Investigation will be used for Fort Hood. SAI will request data tapes for Fort Hood from CERL. At the other three sites, the field test participants will be asked to make a daily meter reading for the first two weeks of the activity and record this information on log sheets (see Section 7).

The estimated energy consumption data will come from the completion of the log sheets by the participants. These will range from a running tabulation of appliance usage (e.g., a dishwasher) to an estimated number of usage hours of an appliance (e.g., an oven). At Fort Hood, the log sheets will be picked up at the end of each month, with the second month's log sheets being distributed as the first month's sheets are collected. At the other sites, the log sheets will be picked up and replaced as the periodic meter readings are taken.

As the data is collected, it will be brought to the SAI project office for collation and storage.

9. DATA ANALYSIS AND PROCESSING

As the data is acquired, it will be checked for any obvious errors. For example, the meter readings will be checked to ensure that the successive readings form an increasing sequence of numbers. The log sheets will be checked in order to identify any potential misunderstanding of the procedures on the part of the participants. Any such matters will be resolved through contact with the participants.

Once the data is verified, it will be entered into computer storage in a format suitable for input to the "norm" calculation procedure. This will be done continuously so that, at the end of the field activities, just one time period's data will remain to be verified and entered.

As soon as the first month's data has been verified and entered, preliminary analysis of the data and "norm" calculation procedure will begin. This will involve "norm" calculation based on the first month's data and comparison of the results with the metered consumption data. The computer program will calculate heating and cooling loads, hot water consumption projections, major appliance electricity use, etc., leading to "norm" projections of electricity and natural gas (or fuel oil) usage. (It is anticipated that there will be no heating loads because the field test will take place during July, August and September.) The results of these comparisons will permit evaluation of the sensitivity of the "norm" to changes in the various parameters describing the dwellings, occupants and usage habits.

If necessary, the "norm" calculation procedure will be refined to improved its predictive capabilities, but it is anticipated that most "norm" refinement work will take place after the field activity ends, when two full months of data are available.

The comparison between "norm" calculations and actual metered consumption data will be made using the following general methodology:

> The main statistic of interest is the size of the variation between the calculated electricity and fossil fuel "norms" and the actual metered consumption data. (Recognizing the approximative nature of the participants' estimated appliance usage, this variation is expected to be nonzero in all cases.) The results will be summarized using histograms to show the frequency of each different magnitude of percent variation from the meter data. The overall sample variances will be computed, and significant deviations will be investigated on a case-by-case basis with reference to the original data for possible explanation. In such cases, the "norm" will be separated into its component parts, and each part will be compared with the usage data in order to resolve any major differences. If necessary, the "norm" calculation procedure will then be revised in order to achieve an acceptable level of variation. This revised "norm" will constitute the finalized version of the "norm". If changes were necessary, the new "norm" will then be re-evaluated in terms of the values it assumes when the input variables take on extreme values (individually and combined) in order to insure reasonable calculational results.

10. REPORTING

The reporting for the field test task will consist of

a) this field test program plan,

b) the test data and a brief description of the data,

c) the results of the evaluation of the field test data, and

d) a summary of the accuracy statistics of the finalized "norm".

The reporting will be done in parallel with the evaluation and finalization of the "norm."

11. FIELD TEST TASK ORGANIZATION AND SCHEDULING

The organization chart for the field test task is shown in Figure 5. The allocations of personnel and man-hours to each of the five subtasks are presented in Table 1. The calendar of field test task milestones is shown in Figure 3.

THE NORM PROGRAM FIELD TEST
Fort Eustis, Virginia
July 13 - Sept. 14, 1979

We at Science Applications, Incorporated would like to express our appreciation for your willingness to participate in this energy consumption field test program. Our goal is to improve the ability of your base to accurately predict household energy needs. In order to do this, it is necessary to test the procedure which makes the predictions. This is where your cooperation is so valuable.

You are being requested to help out by keeping track of some of your household energy uses for the next two months. We will use this information along with information about the weather, your residence and your appliances in order to predict how much energy you will be using. By comparing these predictions with your meter readings, we will be able to check the accuracy of the predictions.

We are not asking that you make any drastic cuts in your energy consumption. All we ask is that you keep a record of what you do consume. For this purpose, we are providing you with log sheets on which to record the number of times per day that you use some of your major appliances. If you do not have some of these appliances, simply leave the corresponding spaces blank. There are spaces for your estimates of the number of hours your television, oven and range were turned on, the number of hours your house was vacant that day, and a daily temperature recording from your indoor thermometer. Starting on Monday, July 13, we ask that you also record the readings on your utility meters each day at 3 p.m. for the first two weeks of the field test. Special sheets have been provided for this purpose.

One of our staff members will return to your house each Monday to pick up your old log sheets, give you new ones and answer any questions you may have. If you have questions at any other times, please call your Base Housing Office at nnn-nnnn, tell them that you have a question regarding the NORM Program Field Test, and leave your name and phone number. We will get in touch with you as soon as possible.

Again, thank you very much for your cooperation.

Figure 1 Introductory Page

AGREEMENT TO PARTICIPATE IN THE NORM FIELD TEST ACTIVITY

The objective of the NORM field test activity is to record information on the consumption of energy in each participant household and make this information available to Science Applications, Inc. (SAI). The field test activity will take place from July 16, 1979 through September 16, 1979. Participation in the field test activity will consist of the following:

1. There will be an initial interview with personnel from SAI during which certain information will be collected regarding the participant's dwelling, appliances and family.

2. The participant will record certain energy consumption data each day on a form provided by SAI. The form for the week July 16-22, 1979 is attached.

3. From July 16, 1979 through July 29, 1979, the participant will make a daily reading of the participant's utility meter(s) and record the readings on a form provided by SAI. The form(s) for the week July 16-22, 1979 is(are) attached.

4. The participant will make each week's forms available to an SAI staff member who will come to the participant's home each Monday starting on July 23, 1979. The SAI staff member will collect the past week's forms, distribute the next week's forms and read the utility meter(s).

In consideration for the above services, the participant will receive a check from SAI for fifty (50) dollars at the end of each month, making a total of one hundred (100) dollars for the entire field test activity.

Participant Signature	Date
Science Applications, Inc., Representative	Date

Figure 2 Agreement to Participate

NORM FIELD TEST

LOG SHEET

JULY 16 - JULY 22

Name: ______________________

Street Address: ______________________

MONDAY - JULY 16

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

TUESDAY - JULY 17

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

WEDNESDAY JUL[illegible]

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

THURSDAY - JULY 19

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

FRIDAY - JULY 20

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

SATURDAY - JULY 21

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

SUNDAY - JULY 22

OVEN:	______	HOURS
RANGE:	______	HOURS
TELEVISION:	______	HOURS
HOUSE VACANT:	______	HOURS
SHOWER/BATH:	______	TIMES
DISHWASHER:	______	TIMES
CLOTHES WASHER:	______	TIMES
CLOTHES DRYER:	______	TIMES
TEMPERATURE AT	______	A.M. P.M.
WAS	______	°F

NOTES:

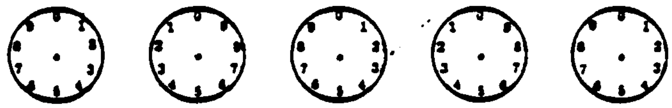
Figure 3 Appliance Usage Log Sheet

NORM Field Test Electric Meter Readings
July 16–July 22

Name: ______________________

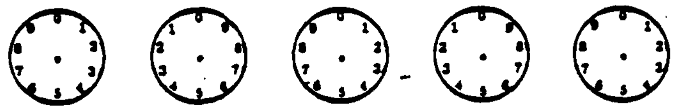
Street
Address: ______________________

MONDAY
July 16
a.m.
______ p.m.



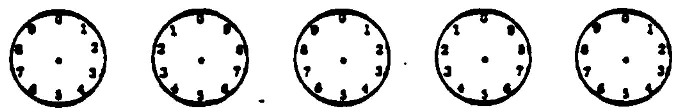
NOTES:

TUESDAY
July 17
a.m.
______ p.m.



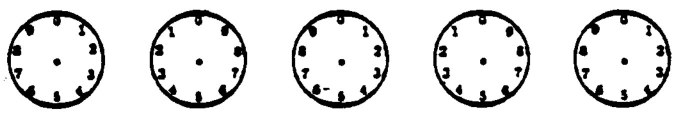
NOTES:

WEDNESDAY
July 18
a.m.
______ p.m.



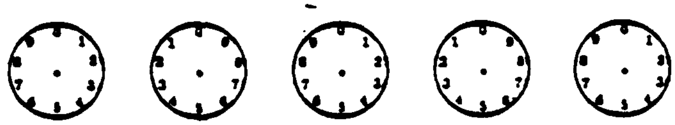
NOTES:

THURSDAY
July 19
a.m.
______ p.m.



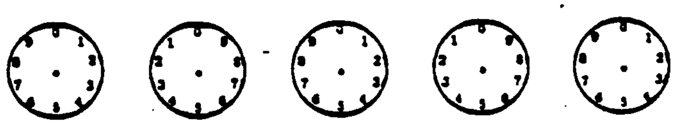
NOTES:

FRIDAY
July 20
a.m.
______ p.m.



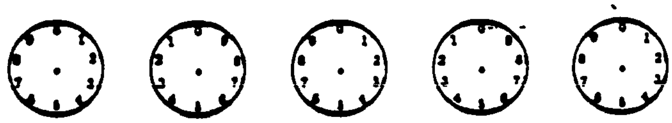
NOTES:

SATURDAY
July 21
a.m.
______ p.m.



NOTES:

SUNDAY
July 22
a.m.
______ p.m.



NOTES:

Figure 4. Meter Reading Log Sheet

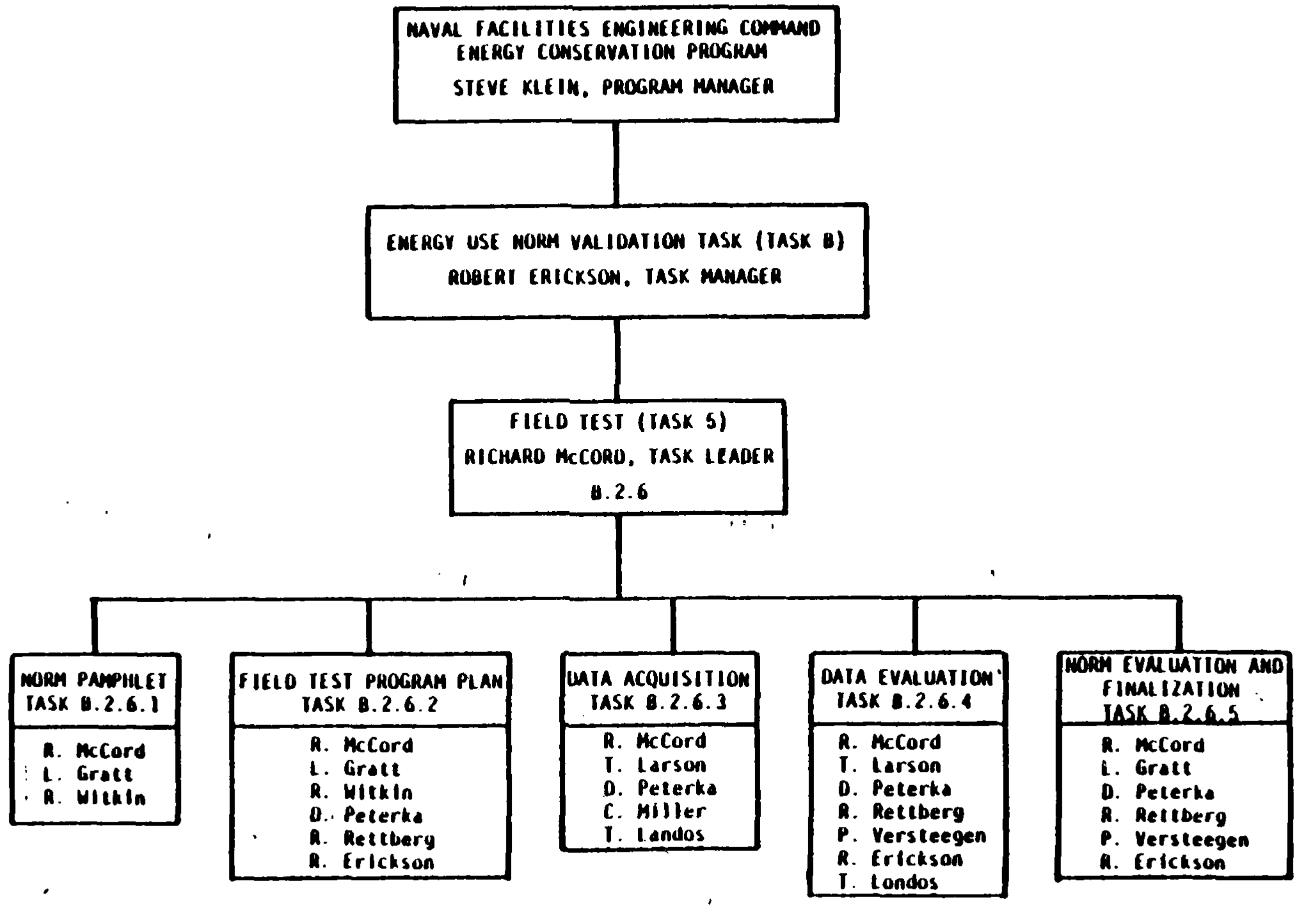


Figure 5 Field Test Task Organization

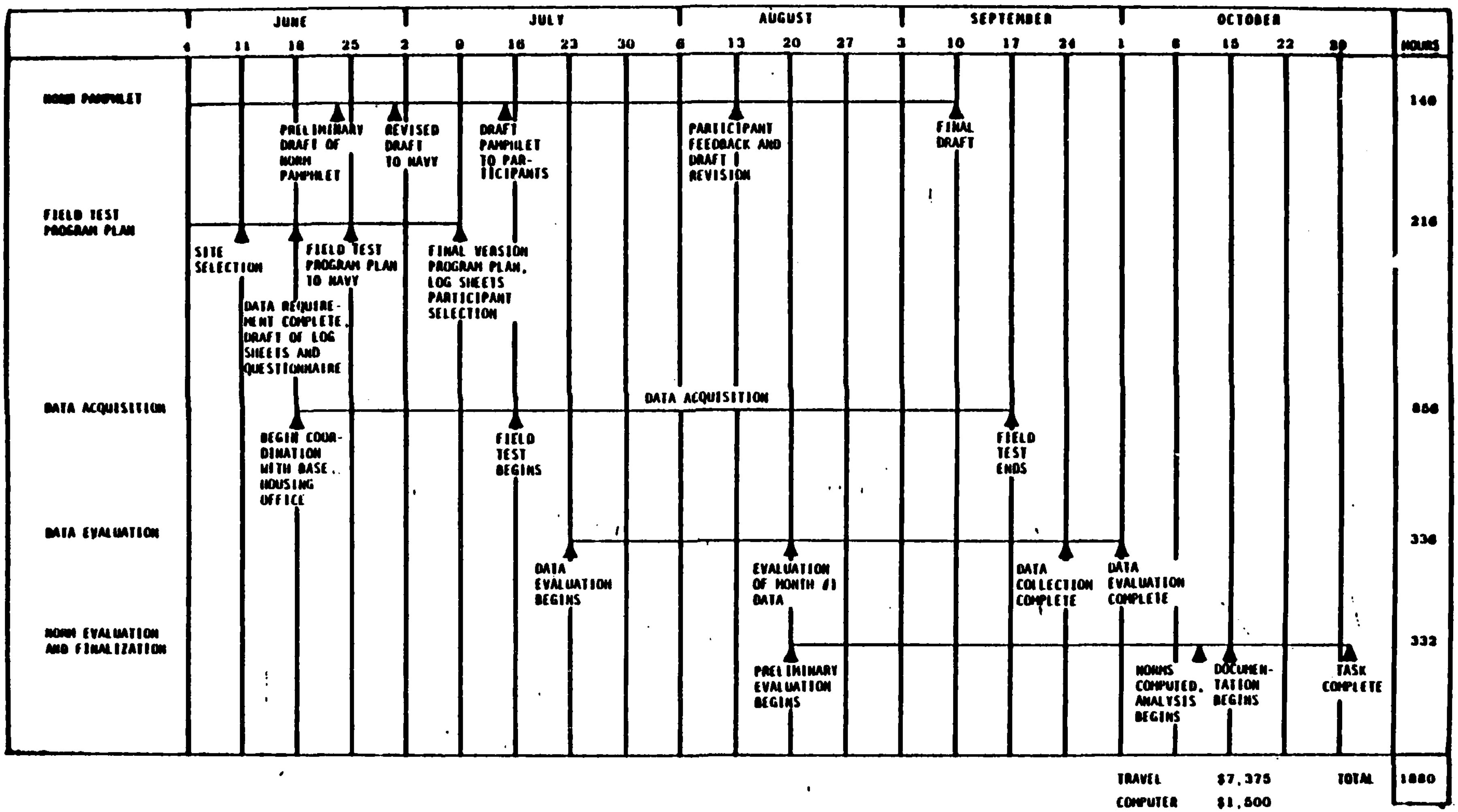


Figure 6 Schedule for Field Test (Task 5)

Table 1 Manpower Allocations by Subtask

NAME	B.2.6 SUBTASK MANHOURS					ROLE/COMMENT
	1	2	3	4	5	
R. McCord	16	80	140	80	160	Task Leader
L. Gratt	8	16			16	Program Design
R. Witkin	56	20				Pamphlet, Technical Editor
T. Londos			160			Data Acquisition/Site A
T. Larson			160	20		Data Aquisition/Site B
D. Peterka		40	160	40	24	Data Acquisition/Site C
C. Miller			160	40		Data Acquisition/Site D
R. Rettberg		8		80	60	Norm Evaluation, Finalization
P. Versteegen				16	16	Norm Evaluation, Finalization
R. Erickson		20		20	16	Program Design
Graphics	20	8				
Typing/Secretarial	40	24	76	40	40	
Totals	140	216	856	336	332	

APPENDIX D

EXAMPLES OF LOG BOOKS

RESIDENT INFORMATION REQUIREMENTS

AND

APPLIANCE DATA SHEETS

MONDAY - AUGUST 27

NUMBER OF MEALS: 4 BREAKFASTS 4 LUNCHES 5 DINNERS

TOTAL OVEN HOURS: 35 min TOTAL MICROWAVE OVEN HOURS: ______

TELEVISION SET #1 11 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: 3 USES CLOTHES DRYER: 3 USES

HOURS OF HOUSE VACANCY: ______

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______

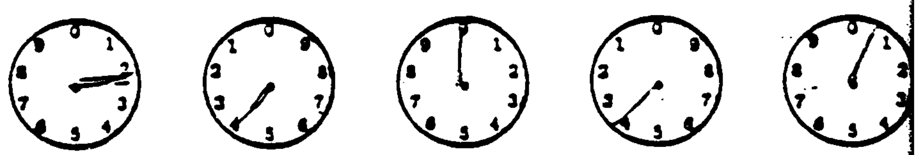
SETBACK TO: ______ °F

TEMPERATURE AT: 11:0 A.M. P.M. 80 °F, AT: 9:15 A.M. P.M. 80 °F

NUMBER OF SHOWERS: 3 NUMBER OF BATHS: 1

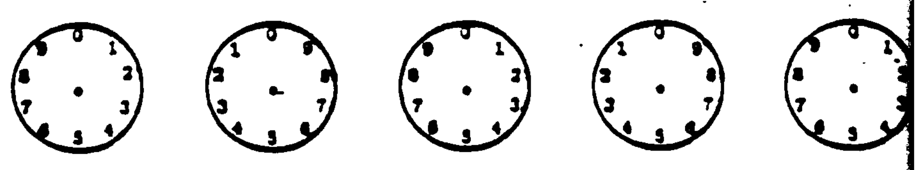
ELECTRIC METER: Digital: ______

9:15 A.M. P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ______

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

______

TUESDAY - AUGUST 28

NUMBER OF MEALS: 6 BREAKFASTS 7 ~~8~~ LUNCHES 4 DINNERS

TOTAL OVEN HOURS: ~~Broiler~~ 15 mins TOTAL MICROWAVE OVEN HOURS: ______

TELEVISION SET #1 11 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 2 USES

CLOTHES WASHER: ______ USES CLOTHES DRYER: ______ USES

HOURS OF HOUSE VACANCY: ______________________________

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______________________

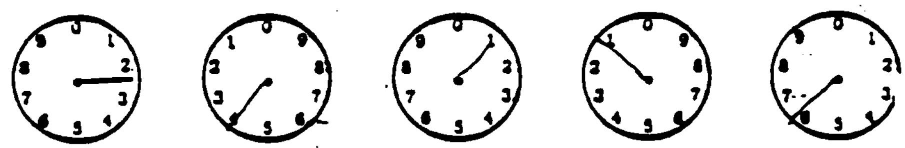
SETBACK TO: ______________ °F

TEMPERATURE AT: 11:30 A.M. P.M. 78 °F, AT: 8:30 A.M. P.M. 80 °F

NUMBER OF SHOWERS: 1 NUMBER OF BATHS: 2

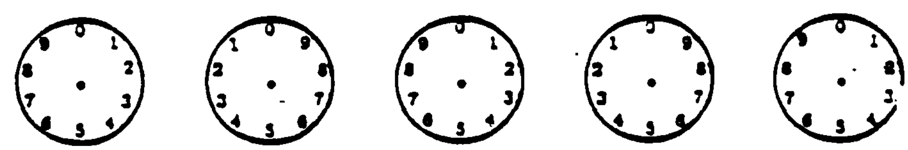
ELECTRIC METER: Digital: ______________

8:30 A.M. P.M. Or Dial:



GAS OR FUEL OIL
METER: Digital: ______________

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

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____

WEDNESDAY - AUGUST 29

NUMBER OF MEALS: 6 BREAKFASTS 7 LUNCHES 5 DINNERS

TOTAL OVEN HOURS: — TOTAL MICROWAVE OVEN HOURS: ______

1½

TELEVISION SET #1 11 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: — USES CLOTHES DRYER: — USES

HOURS OF HOUSE VACANCY: ______

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______

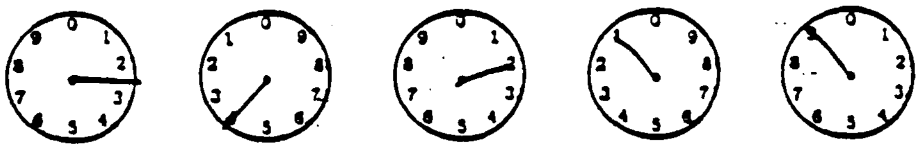
SETBACK TO: ______ °F

TEMPERATURE AT: 11:15 A.M. 80 °F, AT: 9:00 P.M. 80 °F

NUMBER OF SHOWERS: 3 NUMBER OF BATHS: 1

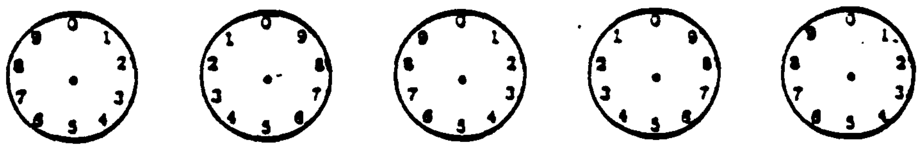
ELECTRIC METER: Digital: ______

9:00 P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ______

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

THURSDAY - AUGUST 30

NUMBER OF MEALS: 5 BREAKFASTS 5 LUNCHES 5 DINNERS

TOTAL OVEN HOURS: — TOTAL MICROWAVE OVEN HOURS: ______

TELEVISION SET #1 10 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: 4 USES CLOTHES DRYER: 4 USES

HOURS OF HOUSE VACANCY: ______

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______

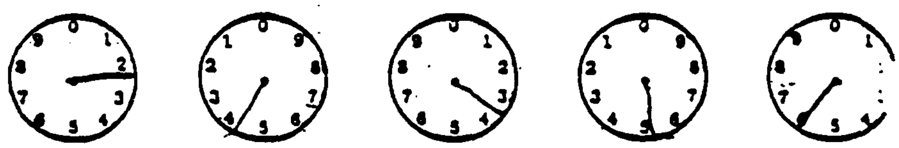
SETBACK TO: ______ °F

TEMPERATURE AT: 11:00 A.M. P.M. 78 °F, AT: 6:00 A.M. P.M. 80 °F

NUMBER OF SHOWERS: ______ NUMBER OF BATHS: ______

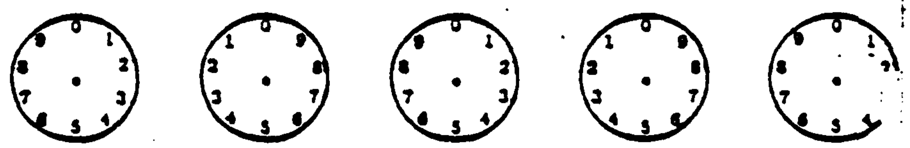
ELECTRIC METER: Digital: ______

12:00 A.M. P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ______

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

______

______

______

______

______

FRIDAY - AUGUST 31

NUMBER OF MEALS: 5 BREAKFASTS 1 ~~3~~ LUNCHES — DINNERS

TOTAL OVEN HOURS: — TOTAL MICROWAVE OVEN HOURS: —

TELEVISION SET #1 3 9 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: ______ USES CLOTHES DRYER: ______ USES

HOURS OF HOUSE VACANCY: ____________________

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ____________________

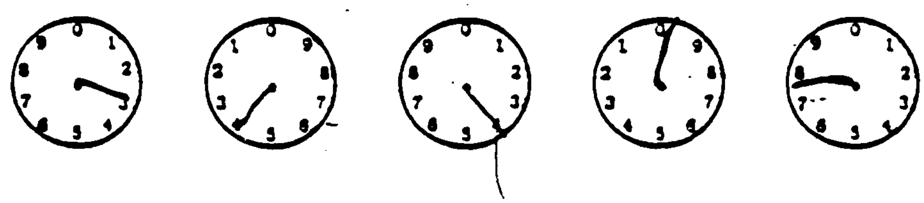
SETBACK TO: __________ °F

TEMPERATURE AT: 11:10 A.M. P.M. 78 °F, AT: 8:15 A.M. P.M. 80 °F

NUMBER OF SHOWERS: 2 NUMBER OF BATHS: 2

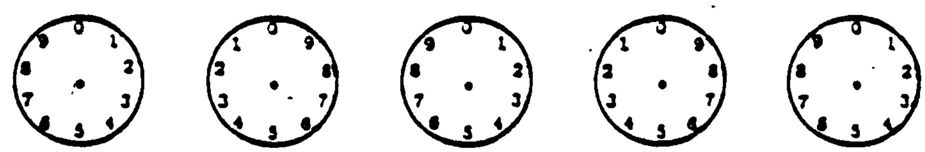
ELECTRIC METER: Digital: ______________

8:15 A.M. P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ______________

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

____

____

____

____

____

SATURDAY - SEPTEMBER 1

NUMBER OF MEALS: 4 BREAKFASTS 8 LUNCHES 4 DINNERS

TOTAL OVEN HOURS: 35 min TOTAL MICROWAVE OVEN HOURS: ______

TELEVISION SET #1 13 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: 4 USES CLOTHES DRYER: 4 USES

HOURS OF HOUSE VACANCY: ______________________

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______________________

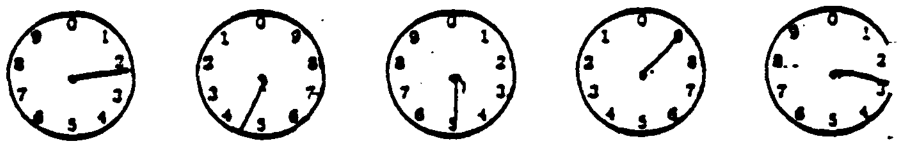
SETBACK TO: ____________ °F

TEMPERATURE AT: 11:10 A.M. P.M. 78 °F, AT: 9:30 A.M. P.M. 78 °F

NUMBER OF SHOWERS: 1 NUMBER OF BATHS: 3

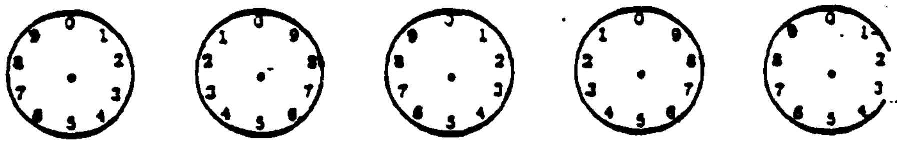
ELECTRIC METER: Digital: [illegible]

9:30 A.M. P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ____________

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

SUNDAY - SEPTEMBER 2

NUMBER OF MEALS: 4 BREAKFASTS 5 LUNCHES 5 DINNERS

TOTAL OVEN HOURS: 2½ TOTAL MICROWAVE OVEN HOURS: ______

TELEVISION SET #1 14 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: — USES CLOTHES DRYER: — USES

HOURS OF HOUSE VACANCY: ______________________

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______________________

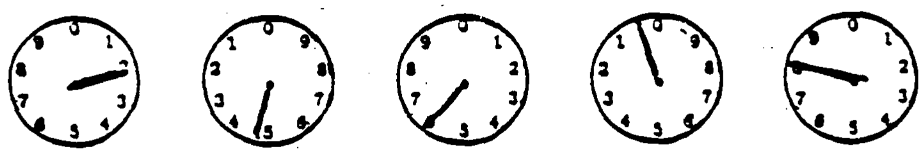
SETBACK TO: ____________ °F

TEMPERATURE AT: 11:00 A.M. P.M. 78 °F, AT: 8:30 A.M. P.M. 76 °F

NUMBER OF SHOWERS: 3 NUMBER OF BATHS: 1

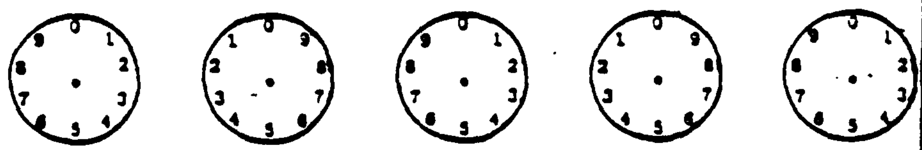
ELECTRIC METER: Digital: ____________

8:30 A.M. P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ____________

______ A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

____

____

____

____

____

MONDAY - SEPTEMBER 3

NUMBER OF MEALS: 4 BREAKFASTS — LUNCHES 5 DINNERS

TOTAL OVEN HOURS: Burner 15 TOTAL MICROWAVE OVEN HOURS: ______

TELEVISION SET #1 15 HOURS TELEVISION SET #2 ______ HOURS

DISHWASHER: 1 USES

CLOTHES WASHER: 6 USES CLOTHES DRYER: 6 USES

HOURS OF HOUSE VACANCY: ______

HOURS OF CENTRAL AIR CONDITIONER SETBACK: ______

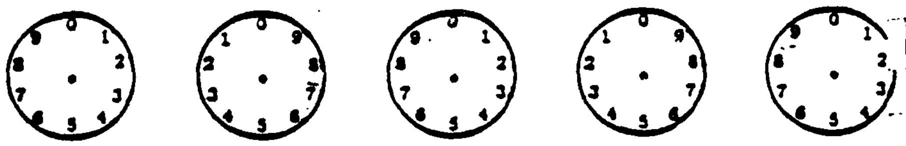
SETBACK TO: ______ °F

TEMPERATURE AT: 11:15 A.M. P.M. 78 °F, AT: 7:30 A.M. P.M. 78 °F

NUMBER OF SHOWERS: 2 NUMBER OF BATHS: 2

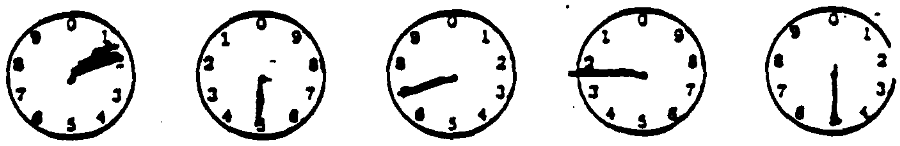
ELECTRIC METER: Digital: ______

______ A.M. P.M. Or Dial:



GAS OR FUEL OIL METER: Digital: ______

7:30 A.M. P.M. Or Dial:



NOTES (Include any other uses you think could be significant):

______

______

______

______

______

RESIDENT INFORMATION REQUIREMENTS

AME: ____________________

ADDRESS: ____________________

1. What is the highest educational level of the service member?
   1. Elementary school
   2. Some high school
   3. High school graduate or equivalent
   4. Some college
   5. Bachelor's degree
   6. Some graduate work or advanced degree

2. What is the age of the service member?
   1. Under 18
   2. 18-25 years
   3. 26-30 years
   4. 31-40 years
   5. 41-50 years
   6. Over 50 years

3. What is the pay grade of the service member?

A. E1	J. W1	N. 01
B. E2	K. W2	O. 02
C. E3	L. W3	P. 03
D. E4	M. W4	Q. 04
E. E5		R. 05
F. E6		S. 06
G. E7		T. 07 or over
H. E8		
I. E9		

4. What is the age of the service member's spouse?
   0. Not applicable—no spouse
   1. Under 18
   2. 18-25 years
   3. 26-30 years
   4. 31-40 years
   5. 41-50 years
   6. Over 50 years

5. What is the highest educational level of the service member's spouse?
   1. Elementary school
   2. Some high school
   3. High school graduate or equivalent
   4. Some college
   5. Bachelor's degree
   6. Some graduate work or advanced degree

6. How long have you lived in your present residence?

1. 0-2 months
2. 3-6 months
3. 7-9 months
4. 10-12 months
5. 13-15 months
6. 16-18 months
7. 19-21 months
8. 22-24 months
9. Over 24 months

7. How many people live in your home (include yourself and all those you expect to live with you at least 6 months)?

1. 1 only
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. 9 or more

8. How old are your children?

____

____

____

____

____

9. How many days during an average week does a member of your family stay at home for most of the day?

0. 0
1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7

OPEN ENDED QUESTION

10. Is there any feature of your home which might cause higher than normal energy consumption?

1. Heating thermostats that are not adjustable.
2. Windows or doors that do not close tightly.
3. Poorly placed heating vents.
4. Cracks in floors, walls, ceilings, etc.
5. Refrigerator or oven doors that do not have a tight seal.
6. Poorly placed heater thermostats.
7. Hot water faucets that drip.
8. Drapes, shades or curtains missing.
9. Cracked or broken windows.
10. Inadequate insulation in housing.
11. Other (Specify ______________________________).

NOTE: We are not in a position to fix anything but the NORM!

Name________________________ Address________________________

Base________________________

A. SUBROUTINE DISHWASHERS

Inputs: A.1 Manufacturer ________________________

A.2 Model Number ________________________

A.3 Year ________________________

A.4 Watts ________________________

A.5 Amps ________________________

Power Dry/Energy Saver:

A.6 Yes/No ________________________

A.7 % of loads with power dry ____________

A.8 Watts ________________________

A.9 Built-In/Portable ________________________

B. SUBROUTINE MICROWAVE OVEN

Inputs: B.1 Manufacturer ________________________

B.2 Model Number ________________________

B.3 Year ________________________

B.4 Watts ________________________

B.5 Amps ________________________

C. SUBROUTINE STANDARD OVEN

		Oven 1	Oven 2
Inputs: C.1	Manufacturer	________	________
C.2	Model Number	________	________
C.3	Year	________	________
C.4	Watts	________	________
C.5	Amps	________	________
C.6	Btu Input	________	________
C.7	Number of Ovens	________	________
C.8	Self Cleaning	________	________
C.9	Pilot Light Ratings	________	________
	Pilot Light Types		
C.10	Standby	________	________
C.11	Intermittent	________	________

D. SUBROUTINE RANGE

Inputs: D.1 Manufacturer ______________________

D.2 Model Number ______________________

D.3 Year ______________________

D.4 Watts ______________________

D.5 Amps ______________________

D.6 Btu Input ______________________

D.7 Number of Burners ______________________

D.8 Number of Pilot Lights ______________________

D.9 Pilot Light Ratings ______________________

Pilot Light Type

D.10 Standby ______________________

D.11 Intermittent ______________________

D.12 Smooth Top/Regular ______________________

D.13 Hood Fan/Lights ______________________

E. SUBROUTINE CLOTHES DRYER

Input: E.1 Manufacturer ______________________

E.2 Model Number ______________________

E.3 Year ______________________

E.4 Watts ______________________

E.5 Amps ______________________

E.6 Btu Input Rating ______________________

E.7 Compact/Standard/Portable ______________________

E.8 Pilot Light Rating ______________________

Pilot Types

E.9 Standby ______________________

E.10 Intermittent ______________________

Dryer Temperature

E.11 % High ______________________

E.12 % Low ______________________

Dryer Cycle

E.13 % Regular ______________________

E.14 % Delicate ______________________

E.15 % Permanent Press ______________________

F. SUBROUTINE CLOTHES WASHERS

Inputs: F.1 Manufacturer ________________
F.2 Model Number ________________
F.3 Year ________________
F.4 Watts ________________
F.5 Amps ________________
F.6 Compact/Standard/Portable ________________
Wash Temperatures
F.7 % Hot ________________
F.8 % Warm ________________
F.9 % Cold ________________
Rinse Temperature
F.10 % Hot ________________
F.11 % Warm ________________
F.12 % Cold ________________

G. SUBROUTINE TELEVISIONS

			Primary Set	Secondary Set
Inputs:	G.1	Manufacturer	________	________
	G.2	Model Number	________	________
	G.3	Year	________	________
	G.4	Watts	________	________
	G.5	Amps	________	________
	G.6	Color/B & W	________	________
	G.7	Instant On/NonInstant On	________	________
	G.8	Size (19" etc.)	________	________
	G.9	Solid State: Yes/No	________	________

H. SUBROUTINE FREEZERS

Inputs:	H.1	Manufacturer ______________________
	H.2	Model Number ______________________
	H.3	Year ______________________
	H.4	Watts ______________________
	H.5	Amps ______________________
	H.6	FEA/DOE/FTC Estimated Energy Consumption ______ ______________________
Type:	H.7	Upright ______________________
	H.8	Chest ______________________
		Defrost:
	H.9	Automatic ______________________
	H.10	Manual ______________________
	H.11	Location ______________________
	H.12	Volume ______________________
	H.13	Energy Saver Switch ON/OFF/NONE ______________________

Note: Put thermometer in freezer.

I. SUBROUTINE REFRIGERATORS

Inputs: I.1 Manufacturer ______________________________

I.2 Model Number ______________________________

I.3 Year ______________________________

I.4 Watts ______________________________

I.5 Amps ______________________________

I.6 FEA/DOE/FTC Estimated Energy Consumption ______

____

Type: Single Door

I.7 Full Width Freezer ______________________________

I.8 Small U-Type Ice Tray Compartment ______________

Double Door

I.9 Top Freezer ______________________________

I.10 Bottom Freezer ______________________________

I.11 Side by Side ______________________________

Defrost: I.12 Manual

I.13 Partial Automatic (Refrigerated compartment is automatic; freezer compartment manual) ________

I.14 Fully Automatic ______________________________

Volume: I.15 Total Cubic Feet ______________________________

I.16 Refrigerated Cubic Feet ______________________________

I.17 Freezer Cubic Feet ______________________________

Energy Saver Switch

I.18 ON/OFF/NONE ______________________________

J. SUBROUTINE WATER HEATERS Type No. _____

Inputs: J.1 Manufacturer ______________________

J.2 Model Number ______________________

J.3 Year ______________________

J.4 Capacity ______________________

Electric

J.5 Watts ______________________

J.6 Amps ______________________

Gas

J.7 Btu input ______________________

J.8 Pilot Light Rating ______________________

J.9 Standard/Intermittent ______________________

K. SUBROUTINE LIGHTING

Location	General Lighting #Bulbs I/F	General Lighting Total Watts I/F	Special Purpose Lighting #Bulbs I/F	Special Purpose Lighting Total Watts I/F
Kitchen				
Dining Room				
Living Room				
Family Room				
Den				
Bathroom 1				
Bathroom 2				
Master Bedroom 1				
Bedroom 2				
Bedroom 3				
Bedroom 4				
Bedroom 5				
Outdoors				
Hallways				
Other				

How many lamps (I/F) are left on all night? ________

Total Wattage (I/F)? ________

Note: Try to number the bedrooms in decreasing order of size. The master bedroom in this case is the largest bedroom in the house.

Note: Lamps with 3-way bulb - use the middle setting. Do not include refrigerator or oven lights.

L. SUBROUTINE DEHUMIDIFIERS

Inputs:

L.1 Manufacturer ____________________

L.2 Model Number ____________________

L.3 Year ____________________

L.4 Watts ____________________

L.5 Amps ____________________

L.6 Capacity (Pints/day) ____________________

L.7 Location (Living Room, basement, etc.) ____________________

L.8 Is the dehumidifier in use? Yes/No/Sometimes_____

Note: If answer to L.8 is sometimes, the log sheet notes should be expanded to include hours of use.

M. SUBROUTINE HUMIDIFIERS

Inputs:

M.1 Manufacturer ____________________

M.2 Model Number ____________________

M.3 Year ____________________

M.4 Watts ____________________

M.5 Amps ____________________

M.6 Capacity ____________________

M.7 Is the humidifier in use? Yes/No/Sometimes __________

Note: If answer to M.7 is sometimes, the log sheet notes should be expanded to include hours of use.

N. SUBROUTINE CENTRAL AIR CONDITIONER

Input: Indoor Unit

Air Handling Unit

		Entire Unit	Blower (If Accessible)
N.1	Manufacturer		
N.2	Model		
N.3	Year		
N.4	Watts		
N.5	Amps		

Evaporator Coil

N.6	Manufacturer		
N.7	Model		
N.8	Year		
N.9	Capacity		

Outdoor Unit

		Entire Unit	Compressor (If Accessible)
N.10	Manufacturer		
N.11	Model		
N.12	Year		
N.13	Watts		
N.14	Amps		
N.15	Capacity		
N.16	FEA/DOE/FTC Efficiency Rating (EER)		

N. SUBROUTINE CENTRAL AIR CONDITIONER Type No. ______

Input: Indoor Unit

(Blower Motor)

N.1 Manufacturer ______________________

N.2 Model ______________________

N.3 Year ______________________

N.4 Watts ______________________

N.5 Amps ______________________

Coil

N.6 Manufacturer ______________________

N.7 Model ______________________

N.8 Year ______________________

N.9 Capacity ______________________

N.10 Watts ______________________

N.11 Amps ______________________

Outdoor Unit

N.12 Manufacturer ______________________

N.13 Model ______________________

N.14 Year ______________________

N.15 Watts ______________________

N.16 Amps ______________________

N.17 Capacity ______________________

N.18 FEA/DOE/FTC Efficiency Rating (EER) ______________

O. ROUTINE INFORMATION REQUIREMENTS

Input: 0.1 Are there any other important appliances which should be considered? ______________________________

____

____

____

0.2 Do you own a waterbed? ______________________________

Wattage ____________ Usage ______________________

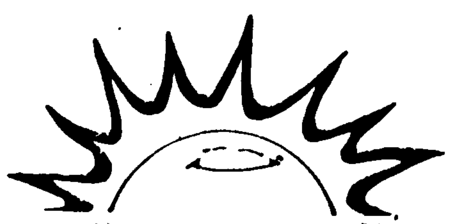
0.3 Do you have any large total residence circulating fans? ______________________________

Wattage ____________ Usage ______________________

APPENDIX E

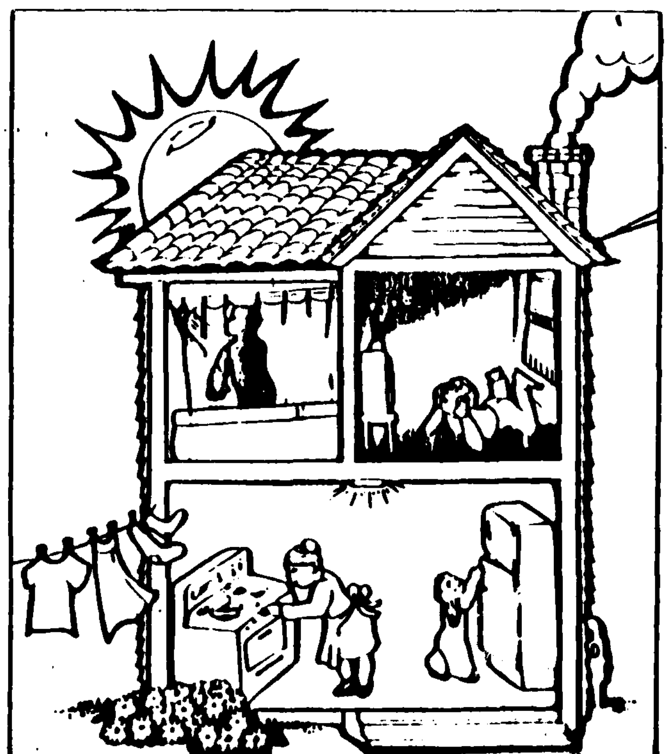
NORM PAMPHLET

(FRONT AND BACK COVERS)



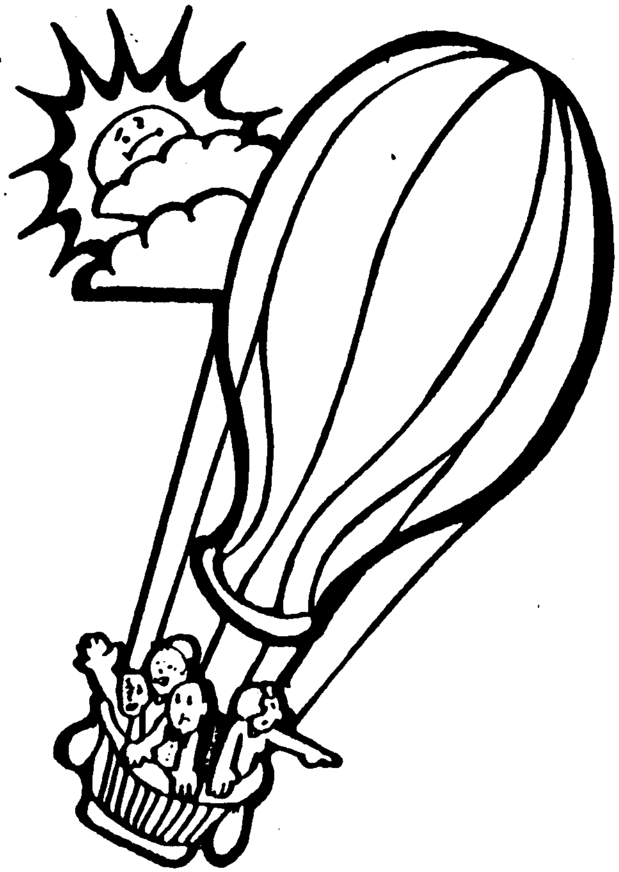
THE ENERGY NORM FOR FAMILY HOUSING

What is it,
and how will it affect you?



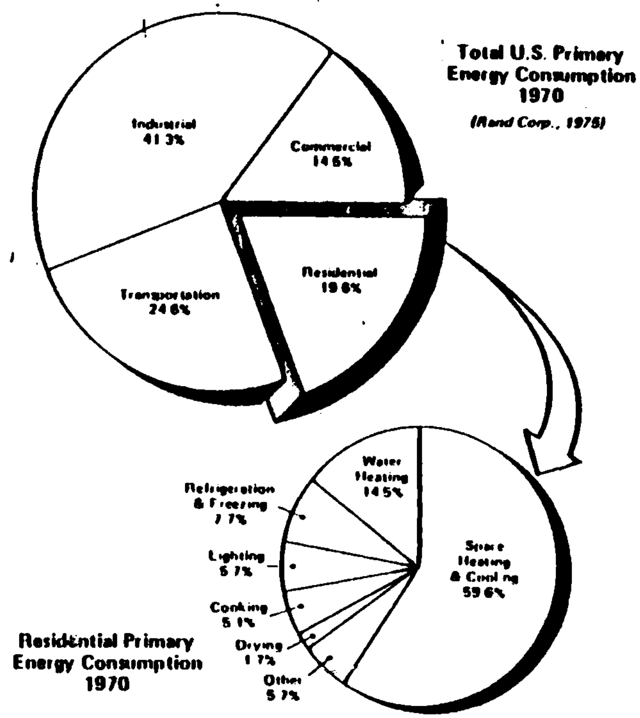
The Energy Picture

The economy of the U.S. is based on energy — primarily natural gas and oil. In order to create these fuels, Nature took millions of years. Unfortunately, we do not have that much time. Our resources are not limitless; these fuels will last perhaps another century. We must begin to conserve our resources now.



Where Does It All Go?

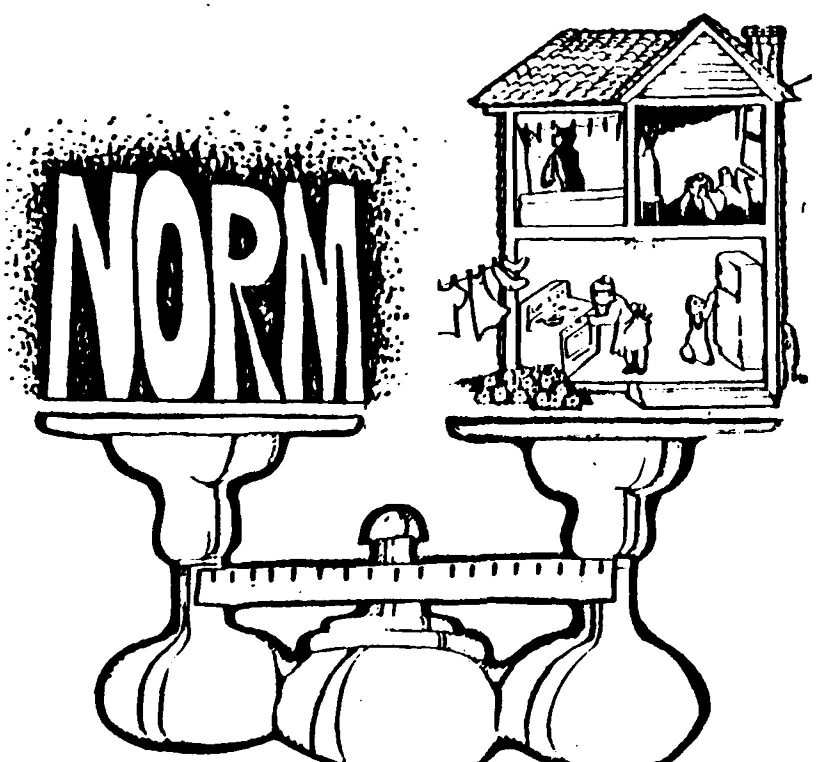
We consume energy at a rapidly increasing rate. In fact, our annual energy consumption has doubled since 1950. Residential usage accounts for nearly 20% of the total energy consumed in the U.S.



In an effort to promote energy conservation, the U.S. Congress passed the Military Construction Act of 1978, which provided for the installation of individual utility meters in military housing. Congress also provided for billing residents on a monthly basis for excess energy consumption and authorized the Department of Defense to develop a fair standard against which to measure consumption. This standard is referred to as an energy consumption "norm" and will serve as a basis for evaluating residential energy use.

What Is A "Norm"?

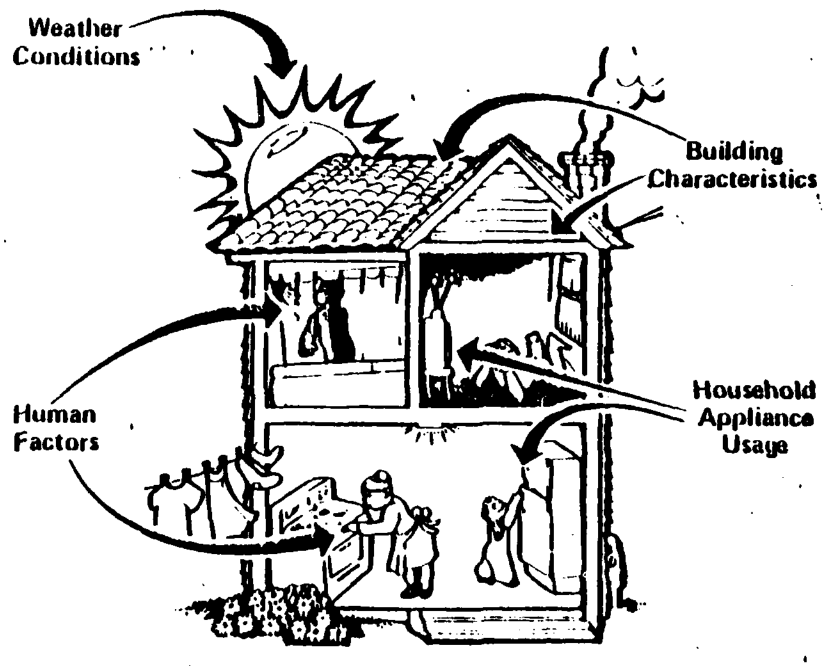
In order to evaluate your energy consumption, a standard usage level has been developed. This standard level is your "norm" and it represents a reasonable amount of energy consumption as reflected by your family's needs — it is not a rationing plan. Factors such as the building characteristics of your home, weather conditions, the size of your family and the types of appliances in your home are taken into account. Thus, your norm is unique to your own situation. When your actual energy usage does not exceed your norm, you are not consuming excessive amounts of energy.



How Was The Norm Developed?

Development of the norm relies heavily on four information sources: building characteristics, weather conditions, household appliance usage and "human factors".

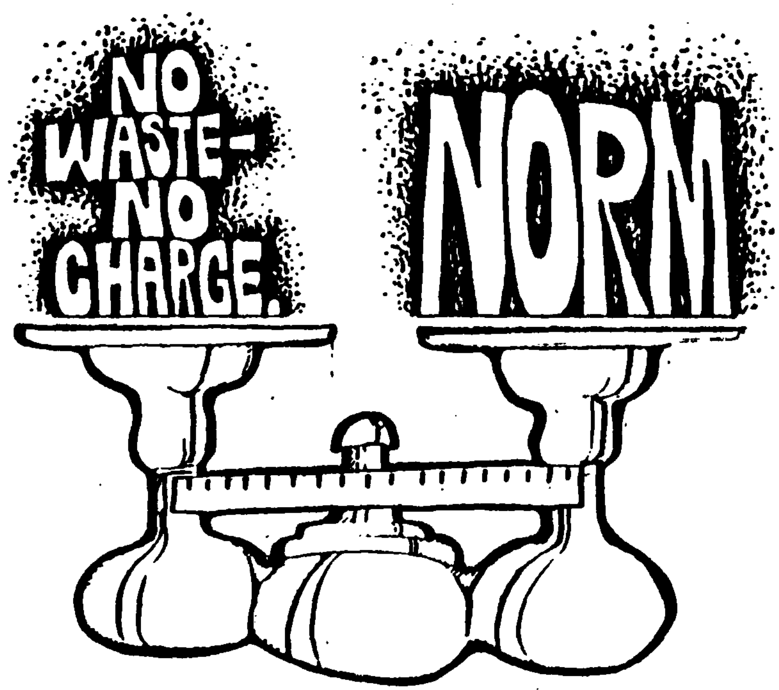
The first input — building characteristics — includes the physical structure of your house, materials used for building and the amount of insulation. Weather conditions include temperature, humidity and wind direction and speed. Household appliance usage refers not only to heating and cooling, but also lighting and major appliance energy usage. For example, your norm will assume that you do not heat your house above 68°F or cool your house below 78°F. The norm will also assume that your water is not heated above 140°F and that you do not light your house excessively. Finally, human factors take into account the size of your family, their ages and occupancy patterns.



E-4

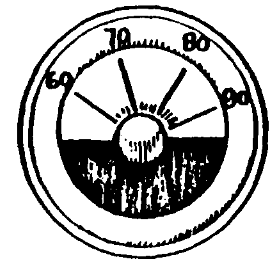
How Will All This Affect Me?

If your energy consumption does not exceed your norm, there will be no effect at all. As we mentioned before, the norm was developed to take into account building quality, number of family members, etc. You will not be penalized for circumstances beyond your control, such as a poorly insulated home or a cold climate. This prescribed level of energy usage will be compared with your actual energy consumption. If your consumption exceeds the norm, Congress has declared that you must be charged for the extra amount. But that doesn't have to happen. Here are a few suggestions on how to save energy and help you stay within the norm to avoid any charges.

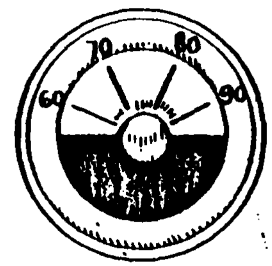


Where Do I Start?

Did you know that space heating and cooling accounts for over half of our total personal energy consumption?



Winter



Summer

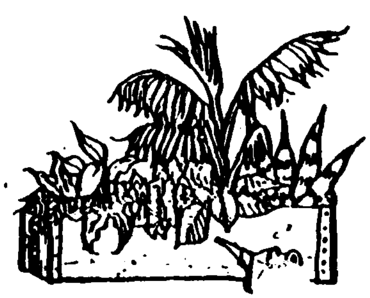
- *Turning down your thermostat one or two degrees will appreciably conserve energy. In the winter, set your thermostat no higher than 65°F during the day and turn it down at night. In the summer, set your thermostat no lower than 78°F. (If you must increase or decrease temperature, setting the thermostat beyond the desired level will not heat or cool your house any faster and will waste energy.)*

- *Do you feel a draft? Install weather stripping around windows and doors to prevent heat loss or gain. If this isn't feasible, use inexpensive clear plastic taped to the inside of windows.*

- *Keep closet doors and doors to unused rooms closed.*

- *Move furniture away from window air conditioners and vents so the air flow will not be blocked.*

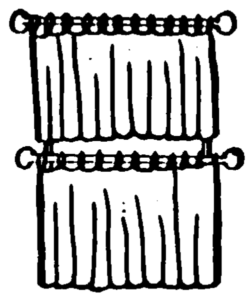
- *A humidifier or a pan of water helps save energy in winter because humidity helps our bodies hold heat. This is a good reason for having lots of house plants, since they also act as humidifiers.*



- *Clean or replace furnace filters when they become clogged with lint. Check them once a month.*

- *When outdoor temperatures permit, turn off the air conditioner and use a fan or the "fan-only" setting. Clean grills and filters on air conditioners.*

- *Close drapes over windows on the shady side of the house during the winter and on the sunny side during the summer, especially if you don't have storm windows.*



HOT WATER USAGE

The water heater is the second largest energy consumer in the house. Careful attention to your hot water usage can therefore save energy.

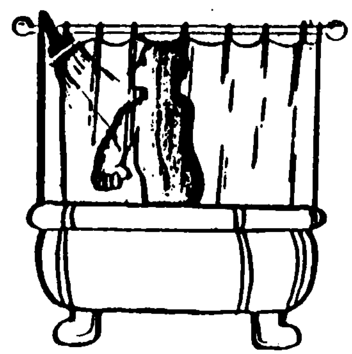
- *Use hot water sparingly. Wasting hot water wastes both the water and the energy used to heat the water.*

- *Set your water heater at 140°F (120°F if you don't have a dishwasher).*

- *Normally you use less water when showering than when bathing. You can save even more water and energy by installing low flow shower heads.*

- *Letting water run while shaving or doing dishes is wasteful. Use sink stoppers and dishpans.*

- *Use warm wash cycles and cold rinse cycles for all washing machine loads, except certain items such as diapers which require hot water.*

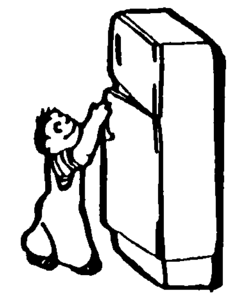


Major Appliances

REFRIGERATORS & FREEZERS

- *Your refrigerator operates most efficiently at 37°–40°F. Open and close the refrigerator door only when necessary.*

- *Frost buildup will make your refrigerator or freezer use more energy. Be sure to defrost the unit when the buildup is ¼–inch thick.*

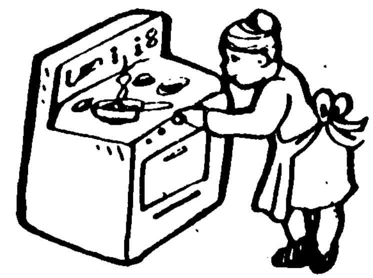


RANGES AND OVENS

- *Turn off your range immediately after use and shut down electric surface units a short time before the food is done. They will stay hot long enough to finish cooking the food.*

- *Don't keep opening the oven door to check the food. Every time you do this, heat escapes and your cooking takes more time and energy.*

- *It is usually unnecessary to preheat your oven.*

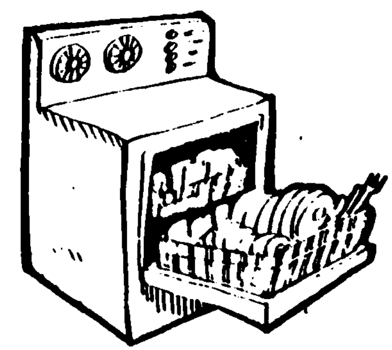


DISHWASHERS

- *Operate only when the dishwasher is filled to capacity. An average family of four needs to run the dishwasher just once each day.*

- *Load your dishwasher properly. Make use of the economy cycles.*

- *Let your dishes air dry. Turn the control knob to "off" after final rinse.*

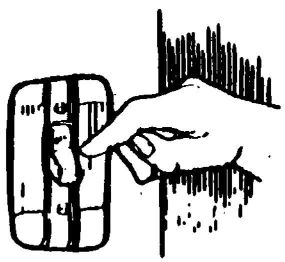


LAUNDRY

- *Operate only when you have a full load. An average family of four uses their washer and dryer eight times per week.*
- *Use a clothesline whenever possible. A clothes dryer can account for up to 5% of a household's total energy use.*
- *Dry clothing in consecutive loads in order to use the leftover heat. Clean the lint filter after each use.*

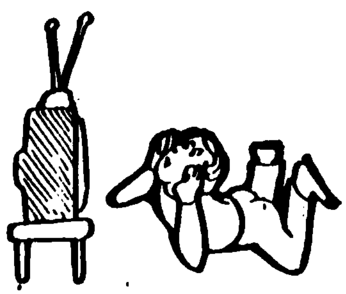
LIGHTING

- *Turn off the lights when you leave a room. It is more energy efficient to turn a light on-and-off several times than to leave it burning.*
- *Solid-state dimmer switches allow more efficient use of energy. If you use 3-way light bulbs, use the lower settings.*



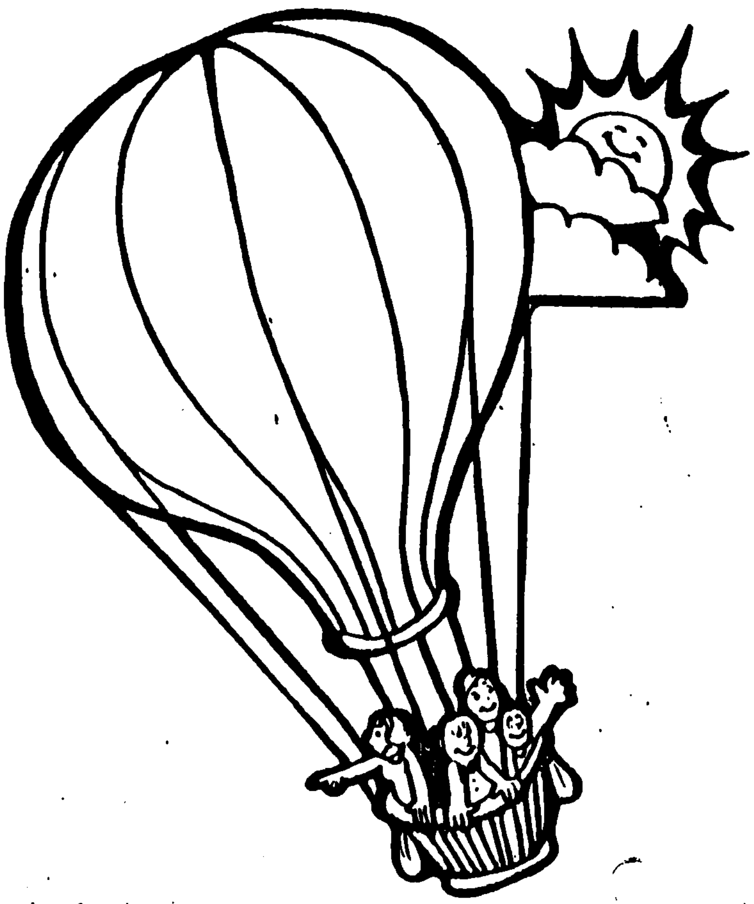
SMALL APPLIANCES

- *Be energy conscious when you shop. Compare wattage ratings of different brands before you buy an appliance.*
- *Turn off your appliances immediately after use.*
- *If your television has an "instant-on" feature, unplug the set when you are planning to be away for a weekend. This feature ensures an instant picture when you turn on the set, but it consumes electricity even when the set is turned off.*
- *Using small kitchen appliances can save energy in preparation of small*



Remember

You can beat the standard by paying more attention to your energy consumption habits. It is time for all of us to do our part to help the nation solve its energy problem.



APPENDIX F

ELECTRICITY AND NATURAL GAS CONSUMPTION CALCULATIONS COMPARED WITH ACTUAL CONSUMPTION

APPENDIX F

ELECTRICITY AND NATURAL GAS CONSUMPTION
CALCULATIONS COMPARED WITH ACTUAL CONSUMPTION

The comparisons of calculated vs. actual energy consumption made in Section 4 represent combined electricity and natural gas consumption for the field test participants. (Recall, however, that Fort Eustis family housing units use only electricity in the cooling season.) This appendix separates total consumption (both calculated and actual) into the electric and natural gas components. The tables presented here for electricity and natural gas consumption are the direct analogues of those in Section 4.

Table F.1 presents the sample means and variances for the percent variations described in Tables F.3 - F.7. Table F.2 lists the sample means and variances for the magnitudes of these percent variations.

Several observations should be made concerning these results, particularly with regard to the summarizing statistics of Tables F.1 and F.2. First, natural gas consumption is underestimated in 36 of the 44 cases listed in Tables F.4 and F.6. This results in the mean variations of -9.4% to -14.9% shown in Table F.1. Natural gas usage at these sites (Great Lakes and Point Mugu) was attributable only to the water heaters, so the underestimates of natural gas usage are consequences of underestimates of family hot water usage. The hot water usage components (bathing, clothes washers, dishwashers, sink use, etc.) were all calculated using "normal" usage projections. Consequently, the underestimates must have resulted from excessive hot water use, high water heater temperature settings, deteriorated water heater efficiencies, or combinations of these factors.

The one-week period at Great Lakes was the only case in which the mean percent variations in Table F.1 indicated a tendency toward overestimation of electricity consumption. These estimates were reduced from Table F.5 to Table F.7 when reported indoor temperature readings were taken into account, but the overestimates remained significant. The large magnitudes of the percent variations in Tables F.5 and F.7 point to the potential for error as the time period under consideration becomes shorter.

Finally, a comparison of Table F.1 with its analogue in Section 4 indicates that the overall percent variations (see Section 4) were frequently the result of underestimating natural gas consumption and either accurately estimating or overestimating electricity usage.

Table F.1. Sample Means and Variances for Percent Variation in Tables F.3-F.7*

TABLE	FORT EUSTIS	GREAT LAKES	POINT MUGU
F.3 (4 Weeks, Electricity)	-10.6% (16.7)	-5.1% (15.2)	-2.5% (16.9)
F.4 (4 Weeks, Natural Gas)	---	-13.0% (17.5)	-14.9% (16.3)
F.5 (1 Week, Electricity)	-13.1% (22.7)	20.7% (27.0)	-7.3% (18.7)
F.6 (1 Week, Natural Gas)	---	-9.4% (18.7)	-12.0% (23.0)
F.7 (1 Week, Electricity, Indoor Temperatures)	-15.2% (13.2)	19.8% (26.3)	---

*Sample variances are in parentheses

Table F.2. Sample Means and Variances for the Magnitude of the Percent Variation in Tables F.3-F.7*

TABLE	FORT EUSTIS	GREAT LAKES	POINT MUGU
F.3 (4 Weeks, Electricity)	16.1% (11.5)	14.7% (6.2)	13.3% (10.7)
F.4 (4 Weeks, Natural Gas)	---	18.0% (12.4)	17.8% (13.2)
F.5 (1 Week, Electricity)	22.9% (12.6)	29.4% (17.2)	17.3% (10.2)
F.6 (1 Week, Natural Gas)	---	16.4% (12.9)	17.5% (19.1)
F.7 (1 Week, Electricity, Indoor Temperatures)	16.6% (11.4)	26.3% (19.7)	---

*Sample variances are in parentheses

Table F.3 Comparison of Calculated and Actual Electricity Consumption for a Four-Week Period

FORT EUSTIS

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1101	6.26	5.36	16.8%
1102	5.83	5.14	13.4
1103	6.39	7.69	-16.9
1104	5.27	5.54	- 4.9
1105	5.83	6.68	-12.6
1106	5.51	7.59	-27.5
1107	6.13	6.40	- 4.2
1108	4.67	8.44	-44.7
1109	4.60	5.11	-10.0
1110	4.24	4.41	- 3.9
1111	6.33	8.15	-22.4

GREAT LAKES

1201	1.67	2.30	-27.4%
1202	1.10	1.16	- 5.2
1203	2.32	1.91	21.0
1204	1.84	2.09	-11.7
1205	1.87	1.97	- 5.3
1206	3.44	4.01	-14.2
1207	4.11	4.85	-15.2
1208	3.48	2.92	19.3
1209	4.04	4.62	-12.7
1210	3.41	3.03	12.6
1211	3.01	3.65	-17.7

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table F.3 (Cont'd) Comparison of Calculated and Actual Electricity Consumption for a Four-Week Period

POINT MUGU

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1401	1.98	1.78	11.1%
1402	1.58	1.71	- 7.9
1403	1.89	2.90	-34.6
1404	1.52	1.56	- 2.3
1405	2.21	2.34	- 5.5
1406	1.98	1.80	10.1
1407	1.94	2.31	-16.2
1408	0.96	0.92	4.6
1409	1.82	2.17	-15.8
1410	1.54	1.61	- 4.8
1411	1.38	1.03	33.5

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table F.4 Comparison of Calculated and Actual Natural Gas Consumption for a Four-Week Period

GREAT LAKES

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1201	3.41	3.88	-11.9%
1202	1.94	3.88	-49.9
1203	3.23	3.47	- 6.9
1204	3.01	4.08	-26.2
1205	3.41	4.08	-16.3
1206	3.63	4.59	-20.8
1207	3.63	3.77	- 3.6
1208	3.63	2.86	27.2
1209	3.63	4.28	-15.2
1210	3.63	4.08	-11.0
1211	3.63	3.98	- 8.7

POINT MUGU

1401	2.27	2.24	1.4%
1402	2.92	3.88	-24.7
1403	3.17	3.47	- 8.5
1404	2.60	3.57	-27.1
1405	2.60	2.86	- 8.9
1406	3.18	3.67	-13.6
1407	2.90	2.65	- 9.6
1408	1.63	1.43	14.3
1409	2.92	3.26	-10.6
1410	3.56	7.34	-51.4
1411	2.81	3.77	-25.6

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table F.5 Comparison of Calculated and Actual Electricity Consumption for a One-Week Period

FORT EUSTIS

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1101	1.57	1.16	36.0%
1102	1.48	1.26	18.2
1103	1.61	1.91	-15.8
1104	1.32	1.51	-12.2
1105	1.48	1.75	-15.4
1106	1.40	2.10	-33.4
1107	1.55	2.10	-25.9
1108	1.19	2.32	-48.7
1109	1.17	1.29	- 9.0
1110	1.07	1.15	- 6.3
1111	1.62	2.35	-31.4

GREAT LAKES

1201	0.43	0.49	-13.3%
1202	0.28	0.22	29.1
1203	0.58	0.44	30.5
1204	0.47	0.47	- 1.5
1205	0.47	0.34	37.6
1206	0.77	0.49	57.1
1207	0.88	1.19	-26.2
1208	0.78	0.49	58.5
1209	0.87	0.67	29.8
1210	0.73	0.55	32.5
1211	0.65	0.70	- 6.9

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table F.5 (Cont'd) Comparison of Calculated and Actual Electricity Consumption for a One-Week Period

POINT MUGU

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1401	0.49	0.45	5.7%
1402	0.38	0.44	-13.4
1403	0.46	0.65	-29.0
1404	0.37	0.41	- 9.4
1405	0.54	0.51	6.4
1406	0.49	0.46	6.2
1407	0.47	0.67	-29.8
1408	0.24	0.20	14.8
1409	0.45	0.53	-15.8
1410	0.37	0.49	-37.9
1411	0.33	0.28	19.5

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table F.6 Comparison of Calculated and Actual Natural Gas Consumption for a One-Week Period

GREAT LAKES

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1201	0.82	0.82	0.7%
1202	0.47	0.82	-42.9
1203	0.78	1.22	-36.3
1204	0.73	0.92	-21.0
1205	0.82	0.71	15.1
1206	0.88	1.02	-14.1
1207	0.88	0.92	- 4.6
1208	0.88	0.71	22.7
1209	0.88	1.02	-14.1
1210	0.88	0.92	- 4.6
1211	0.88	0.92	- 4.6

POINT MUGU

1401	0.55	0.61	-10.0
1402	0.71	0.71	- 1.4
1403	0.77	0.82	- 5.0
1404	0.63	0.92	-31.1
1405	0.63	0.71	-11.4
1406	0.77	0.92	-15.5
1407	0.72	0.71	1.4
1408	0.40	0.31	30.0
1409	0.71	0.71	- 1.4
1410	0.86	0.20	-69.0
1411	0.68	0.82	-16.3

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

Table F.7 Comparison of Calculated and Actual Electricity Consumption for a One-Week Period Using Recorded Indoor Temperatures

FORT EUSTIS

Unit No.	Calculated Consumption (Million Btu)	Actual Consumption (Million Btu)	%Variation*
1101	1.16	1.16	0.3%
1102	1.04	1.26	-16.8
1103	1.58	1.91	-17.5
1104	1.41	1.51	- 6.3
1105	1.31	1.75	-25.3
1106	1.42	2.10	-32.5
1107	1.65	2.10	-21.2
1108	--	2.32	--
1109	1.23	1.29	- 4.4
1110	1.22	1.15	6.8
1111	1.54	2.35	-34.7

GREAT LAKES

1201	0.43	0.49	-13.3%
1202	0.28	0.22	29.1
1203	0.58	0.44	30.5
1204	0.47	0.47	- 1.5
1205	0.47	0.34	37.6
1206	0.82	0.49	69.0
1207	0.93	1.19	-21.3
1208	0.74	0.49	50.1
1209	0.85	0.67	27.3
1210	0.59	0.55	6.6
1211	0.72	0.70	3.4

*The minus ("-") sign indicates that the estimated consumption was below actual consumption.

CLEARANCE

CODE	INITIAL
082A	
0822	
0822B	

OTHER

OFFICIAL FILE COPY

NAVFAC

0822B/SBJ
21 October 1977

MEMORANDUM

From: 082
To: 011

Subj: Testing of Metering Utility Consumption of Military Family Housing Occupants

Encl: (1) Management Specifications

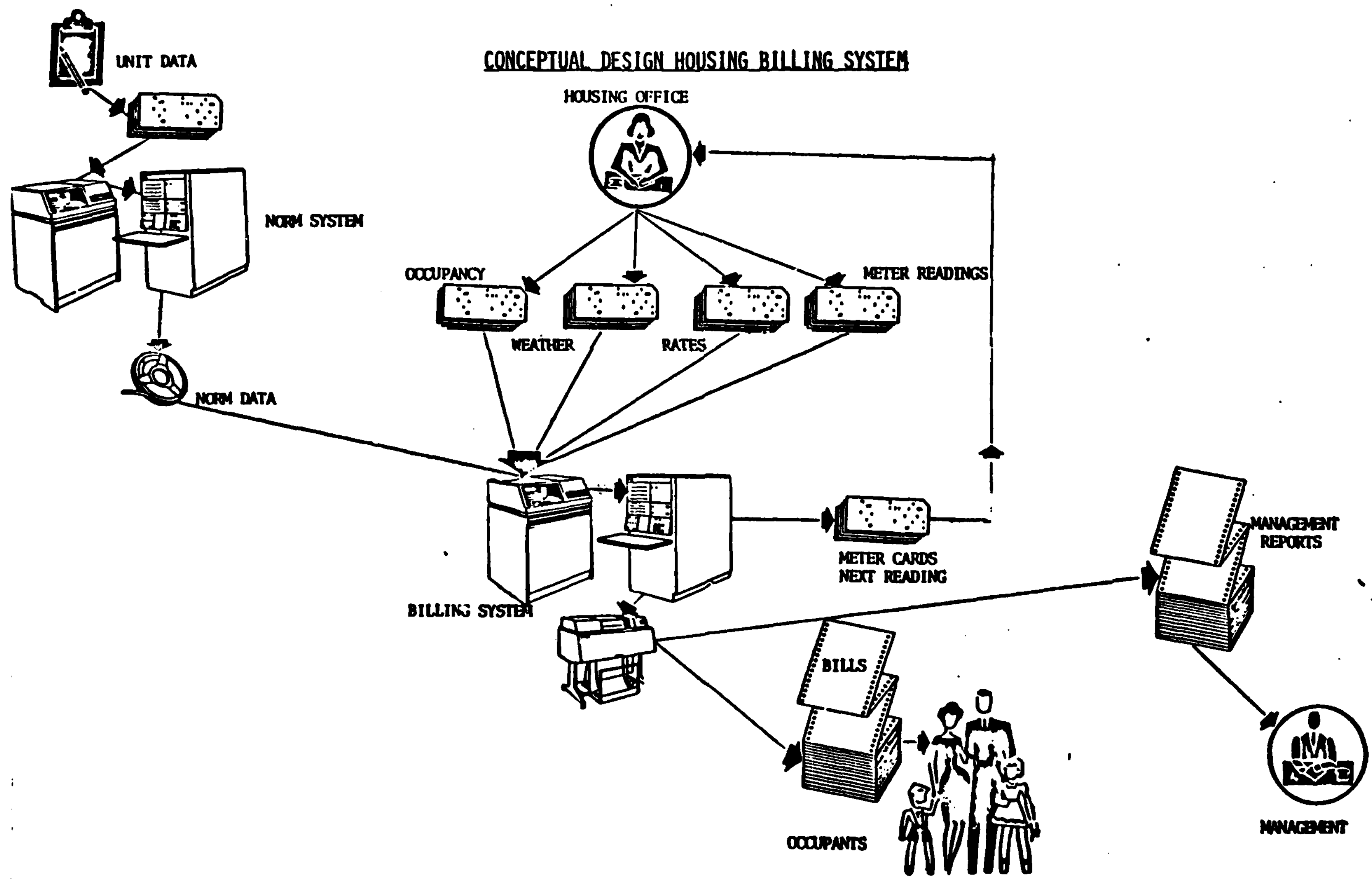
1. Based on prior discussions with you and your staff, enclosure (1) is provided to assist in the design of the ADP portion of the billing system. Enclosure (1) is the initial effort by this office to identify the requirements of the billing system. Additional requirements may be identified after further discussions with your staff.

E. E. GORE

Copy to:
08 Reading File
082 Reading File
0822B Record Copy

Prepared by: S. B. Joyce, 0822B, 50511
Typed by: P. Rison on 20 October 1977

CONCEPTUAL DESIGN HOUSING BILLING SYSTEM



NORM DATA MASTER

Activity Name ____________________
Category of Quarters ____________
Norm Code ________________________
Date of Report ___________________

Address
Meter Number
Building Characteristics:

Address
Meter Number
Building Characteristics:

Address
Meter Number
Building Characteristics:

Address
Meter Number
Building Characteristics:

Address
Meter Number
Building Characteristics:

NORM DATA MASTER

DATA ELEMENT	SOURCE
Activity Name	Master File/Header
Activity UIC	Master File/Header
Category of Quarters	Master File
Norm Code	Master File
Date of Report	Date Report is Run
Address	Master File
Meter Number	Master File
Building Characteristics	Input based on data requirements of "BLAST". Will be updated as the building characteristics change.

Addresses will be grouped by Category of Quarters and Norm Code. Loadsheets will be used to input changes to building characteristics. Report should be printed quarterly. This report will be used by the Housing Office to keep track of all building characteristics which go into making up the norm.

METER CARD

ADDRESS	METER NO.	LOCATION

HI-LO RANGE ( )	PREVIOUS READING	BOOK AND SEQUENCE NO

NEW ADDRESS	NEW SEQUENCE NO.

	0	1	2	3	4	5	6	7	8	9
USAGE	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
VERIFICATION	0									
TYPE OF READING	0	0								
DATE OF READING	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
READER CODE	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
CORRECTION	0									

METER CARD

(Computer will print info in top six blocks before meter reader sees card)

<u>Address</u>. From master file. Identification of the appropriate unit or common usage area.

<u>Meter Number</u>. From master file. A unique seven space number:
Space 1 -Letter designating activity
Space 2-5 - Numbers designating unit
Space 6 - Letter designating type of utility
Space 7 - Number designating source of consumption

<u>Location</u>. From master file. 2 digit code indicating where the meter was placed.

<u>Hi-Lo Range</u>. Calculation. Where daily projected norm x scheduled days in billing period = projected norm for period.

Lo = .5x projected norm for period + previous reading

Hi = 2.0x projected norm for period + previous reading

<u>Previous Reading</u>. From master file

<u>Book and Sequence Number</u>. From reading schedule file. Will place meter in the sequence it will be read.

<u>New Address</u>. To be filled out at time of check-out by meter reader. Place where final bill will be sent. If new address is unknown, send to new command. If person is retiring and new address is unknown, send to address of home of record.

<u>New Sequence Number</u>. To be filled in by meter reader if he wants the card to be sorted in a different order.

<u>Usage</u>. From meter reader input. Meter data will be placed on meter card in the appropriate boxes.

<u>Verification</u>. From meter reader input. If consumption reading for the period fell within the Hi-Lo Range, no marks would be put on meter card. If reading was outside the Hi-Lo Range, meter reader would double check reading and mark the "0" box to indicate the reading was verified.

<u>Type of Reading</u>. From meter reader input. No marks on the meter card are necessary if the reading is the scheduled monthly reading. If reading is done during the check-in mark "0" block. If reading is done during the check-out mark "1" block.

Date of Reading. From meter reader input. Julian date will be used.
Reader Code. From meter reader input. Code of person reading meter.
Correction. The "O" block will be marked when submitting a corrected meter card. This will erase the data on file and enter the corrected data.

Note: Meter cards for the scheduled monthly reading will be printed and placed into meter books in sufficient time for the meter readers to make adjustments to their schedule when necessary. Meter readers will read the meters on a daily basis, review the cards and submit them to ADP. The cards will be run daily and a daily edit run will be prepared (if applicable). All meters (unit, common usage and master) have to be read during the service period. The reading of the family housing master meters will coincide with the station billing cycle. The activity should survey all family housing structures which are subject to meter installation. A plan should be developed to number meters in an orderly fashion although the actual installation may be some time in the future. At the same time, a schedule for reading the meters should be developed which would organize the meters into the proper sequence and book number. A determination needs to be made at the activity as to how many meters can be read in a given day. As new meters are installed they will have to be inputted into the system so that a book and sequence number can be assigned and the meter read. When a meter is replaced, an adjustment will have to be made to the previous reading in the master file before another meter card is printed. The Housing Office should provide the computer within a list of units schedule for occupancy or vacate in order to have meter cards printed for them separately from the scheduled monthly reading. If the Housing Office is unable to provide the computer with a list of units scheduled for change of occupancy in sufficient time to have the cards printed, the person reading the meter should use a blank meter card and fill in all the blocks. If the meter card is to be keypunched vice OP-SCAN, the header information on the meter card can be pre-punched to cut down on keypunch errors.

EDIT REPORT

Activity Name ____________ Service Period ____________

Address	Meter No.	Date of Error	Hi-Lo Range	Pre Reading	Cur. Reading	Verified	Date of Reading	Reader Code
4203 Applecore Road	A0052EO	074	47830-37330	32080	43580		073	01
971 Wayside Dr.	A0187EO	060	58230-47230	41730	58520		058	01
266 Bradford Ct.	A0329E2	046	1255-1205	1180				
137 Kraft Rd.	A0367FO	035	3012-2917	2869	2962		033	02
88 Nuggett La.	A0526GO	051	5374-5249	5186	5386	Yes		01

EDIT REPORT

DATA ELEMENT	SOURCE
Activity Name	Master File/Header
Service Period	Master File. Julian Date
Address	Master File
Meter Number	Master File. 7 digit number
Date of Error	Master File. Date error first appears on edit report
Hi-Lo Range	Calculation. Where daily projected norm x scheduled days in billing period = projected norm for period. Lo = .5x projected norm for period + previous reading Hi = 2.0x projected norm for period + previous reading
Previous Reading	Master File
Current Reading	Meter Card
Verification	Meter Card. If current reading is outside Hi-Lo Range, reading must be verified. If within the range, no verification is required
Date of Reading	Meter Card. Julian Date
Reader Code	Meter Card. Code of person reading the meter

NOTE:

This edit report will be run daily and flag:

1. Missed readings
2. Readings outside Hi-Lo Range not verified
3. Incorrect date of reading

This is a sample of the type of edits we will need. More edits may be identified after further discussions with Management and ADP personnel. A bill is not printed for meter cards which are flagged until the data is corrected or the meter is read. Errors will appear on edit report until corrected. Machine will print report in order of book and sequence number so that errors will appear in the order that the meters will be read. If the bills are produced at a central processing point, the meter cards should be edited before sent out so that only correct cards are processed and correction of errors not delayed.

MOCK UTILITY BILL

Name ______________________
Address ______________________
Meter Number ______________________

Date of Current Reading ____________
Date of Prior Reading ____________
Number of Days Billed ____________

1. Unit of Measure
2. Current Reading
3. Prior Reading
4. Usage This Period
5. Norm for Period
6. Variance for Period
7. Cost Per Unit of Measure
8. Cost of Actual Usage
9. Cost of Norm
10. Cost of Excess Usage
11. Government Cost Above Energy Norm
12. This Is A Test. Do Not Pay.

MOCK UTILITY BILL

Name John R. Smith
Address 13 Cornwall Court
Meter Number 1864

Date of Current Reading 15 Feb 78
Date of Prior Reading 15 Jan 78
Number of Days Billed 31

		ELECTRICITY	GAS	OIL	TOTAL
1.	Unit of Measure	KWH	CCF	GAL	
2.	Current Reading	79470	9438	7649	
3.	Prior Reading	68590	9299	7552	
4.	Usage This Period	11500	139	93	
5.	Norm for Period	10880	125	95	
6.	Variance for Period	+620	+14	-(2)	
7.	Cost Per Unit of Measure	.0052	.21	.475	
8.	Cost of Actual Usage	59.80	29.19	44.18	
9.	Cost of Norm	56.58	26.25	45.13	
10.	Cost of Excess Usage	+3.22	+2.94		$6.16

11. Government Cost Above Energy Norm $6.16

12. This Is A Test. Do Not Pay. $6.16

MOCK UTILITY BILL

DATA ELEMENT	SOURCE
Name	Master File
Address	Master File
Meter Number	Master File
Date of Current Reading	Meter Card - Convert Julian date to Day-Month-Year
Date of Prior Reading	Master File - Day-Month-Year
Number of Days Billed	Calculation. Period from previous reading (from master file) to current reading date (from meter card)
Unit of Measure	Master File
Current Reading	Meter Card
Prior Reading	Master File
Usage this Period	Calculation. Current reading less previous reading.
Norm for Period	Norm Data File
Variance for Period	Usage (line 4) less Norm (line 5)
Cost Per Unit of Measure	Rate Input from Comptroller
Cost of Actual Usage	Calculation. Usage (line 4) x Cost Per Unit of Measure (line 7)
Cost of Norm	Calculation. Norm (line 5) x Cost Per Unit of Measure (line 7)
Cost of Excess Usage	Calculation. Variance (line 6) x Cost Per Unit of Measure (line 7). No calculations will be made for negative numbers in line 6.
Total Cost of Variance	Calculation. Sum of all costs in line 10.

Government Cost Above Energy Norm	Calculation. Sum of all costs in line 10.

NOTE: The bills will be printed on a daily basis according to a schedule developed at least six months in advance. Provision should be made that after the test period the bill will print a statement showing balance of overdue amount. Capability should also exist for printing a statement on the bill that the account is 60 days overdue and specify what action will be taken to collect the money. A list of delinquent accounts will be sent to each Command.

The inputs which will be used to develop a mock bill are:

Projected Monthly Norm - From "BLAST" developed by Army
Appliance and Light Loads - From OSD
Occupancy Data - From Housing Office
Weather Tape - From activity weather data
Meter Readings - From Housing Office

DELINQUENT ACCOUNTS

Activity Name ______________

Activity UIC ______________

Date of Report ______________

				PERIOD OF ACCOUNTS IN ARREARS							
Name	Rank/ Rate	Address	Meter Number	30 Days	60 Days	90 Days	120 Days	150 Days	180 Days	Amt. in Exc. Of 180 Days	Total Arrears

DELINQUENT ACCOUNTS

ACTIVITY NAME PWC Outer Banks, FL
ACTIVITY UIC 61616
DATE OF REPORT 22 Mar 76

NAME	RANK/ RATE	ADDRESS	METER NUMBER	30 DAYS	60 DAYS	PERIOD OF ACCOUNTS IN ARREARS 90 DAYS	120 DAYS	150 DAYS	180 DAYS	AMT IN EXC OF 180 DAYS	TOTAL ARREARS
Edward R. Abrahms	03	1306 Aspen Ct.	1476		6.45						6.45
Paul G. Corey	E4	231 Nuggett La.	0749							3.96	3.96
Warren T. Davies	01	46 Wayside Drive	0677			2.84		11.17			14.01
Gerald R. Franks	E7	550 Browns St.	0832	7.13							7.13
Dolores M. Smythe	E5	137 Kraft Rd.	0340			22.85					22.85
Number of Accounts In Arrears	5										
Total Arrears				7.13	6.45	25.69	Ø	11.17	Ø	3.96	54.40

DELINQUENT ACCOUNTS

DATA ELEMENT	SOURCE
Activity Name	Master File/Header
Activity UIC	Master File/Header
Date of Report	Date Monthly Report is Run Day-Month-Year
Name	Master File
Rank/Rate	Master File
Address	Master File
Meter Number	Master File (4 Digit Number)
Period of Accounts In Arrears	
30 Days - 180 Days	Master File
Amt. in Excess of 180 Days	Master File
Total Arrears	Calculation. Sum of Arrears
Number of Accounts in Arrears	Calculation. Total number of accounts in arrears
Total Arrears	Calculation. Sum of accounts in arrears for each period and sum of each total

NOTE: This report will be printed monthly.

MOVES-IN AND MOVES-OUT LISTING

Activity Name ____________________
Activity UIC ____________________
Date of Report ____________________

Address	Meter Number	Category of Quarters	Date of Check-In	Date of Check-Out

MOVES-IN AND MOVES-OUT

DATA ELEMENT	SOURCE
Activity Name	Master File/Header
Activity UIC	Master File/Header
Date of Report	Date of Weekly Report is Run Day-Month-Year
Address	Master File
Meter Number	Master File
Category of Quarters	Master File
Date of Check-In	Master File. All check-ins since previous report.

Moves-In and Moves-Out will be printed weekly by meter number starting with lowest 4 digit meter number (0001) to the ighest.

ENERGY CONSUMPTION BY UNIT

Activity Name ______________________
Activity UIC ____________________
Category Code ________________
Service Period ____________

							USAGE			Excess
Norm Code	Address	Rank/ Rate	Occupied Days	Vacant Days	Meter Number	Type Utility	Actual	Norm	Variance	Usage Charge

COQ ____/NORM CODE ____

Total of excess usage charges ______
Numb units with excess charges _____

ENERGY CONSUMPTION BY UNIT

Activity Name PWC Outer Banks, FL
Activity UIC 61616
Category Code B
Service Period 3 Feb 78-2 Mar 78

Norm Code	Address	Rank/ Rate	Occupied Days	Vacant Days	Meter Number	Type Utility	USAGE Actual	USAGE Norm	USAGE Variance	Excess Usage Charge
	33A Bluebird Lane	03	30	0	0864	Electric (KWH)				
	Occupied Usage						11500	10880	+620	
	Vacant Usage						0	0	0	
					0865	Gas (C/CF)				
	Occupied Usage						139	125	+ 14	
	Vacant Usage						0	0	0	
						TOTAL				$5.62
1	33B Bluebird Lane	01	30	0	0866	Electric (KWH)				
	Occupied Usage						10999	10880	+119	
	Vacant Usage						0	0	0	
					0867	Gas (C/CF)				
	Occupied Usage						124	125	- 1	
	Vacant Usage						0	0	0	
						TOTAL				$1.03
1	1942 Aspen Road	E7	28	2	1324	Electric (KWH)				
	Occupied Usage						10123	10155	- 32	
	Vacant Usage						106	725	-619	
					1325	Gas (C/CF)				
	Occupied Usage						124	117	+ 7	
	Vacant Usage						2	8	- 6	
						TOTAL				N/A

ENERGY CONSUMPTION BY UNIT

Activity Name PWC Outer Banks, FL
Activity UIC 61616
Category Code B
Service Period 3 Feb 78-2 Mar 78

Norm Code	Address	Rank/ Rate	Occupied Days	Vacant Days	Meter Number	Type Utility	USAGE Actual	USAGE Norm	USAGE Variance	Excess Usage Charge
1	1947 Aspen Road	E8	25	5	1332	Electric (KWH)				
	Occupied Usage						9173	9067	+106	
	Vacant Usage						295	1813	-1518	
					1333	Gas (C/CF)				
	Occupied Usage						122	104	+ 18	
	Vacant Usage						10	8	+ 2	
						TOTAL				$1.27

COQ B /NORM CODE 1

Total of excess usage charges $7.92
Num units with excess charges 3

ENERGY CONSUMPTION BY UNIT

DATA ELEMENT	SOURCE
Activity Name.	From Master File/Header.
Activity UIC.	From Master File/Header.
Category Code.	From Master File.
Service Period.	From Master File.
Norm Code.	From Master File. Norm will be determined using "BLAST" and OSD load profiles. Once the norm has been determined for a unit it is inputted to master file.
Address.	From Master File.
Rank/Rate.	From Master File.
Occupied Days.	Meter Card.
Vacant Days.	Meter Card.
Meter Number.	Frc Master File.
Type Utility.	From Master File.
Usage.	
Actual Occupied	From Meter Card.
Norm Occupied	From Norm Input.
Variance Occupied	Calculation. Actual less norm.
Actual Vacant	From Meter Card.
Norm Vacant	From Norm Input.
Variance Vacant	Calculation. Actual less norm.
Unit Excess Usage Charge	From Utility Bill (line 10)
Summary.	Category of Quarter(COQ)_____/Norm Code_____. From this report.
Total of Excess Charges.	Calculation. Sum of all unit excess usage charges by norm code within a category of quarters.
Number of Units With Excess Charges	Calculation. Sum of units with excess usage charges by norm code within a category of quarters.

NOTE: This is a monthly report. The master file will contain occupancy data which will enable the computer to determine whether a unit is occupied or vacant and for how long.

ENERGY CONSUMPTION BY COMMON USAGE

Activity Name ______________________

Activity UIC ________________

Service Period ___________

Address	Meter Number	Type Utility	Actual Usage

ENERGY CONSUMPTION BY COMMON USAGE

DATA ELEMENT	SOURCE
Activity Name	Master File/Header
Activity UIC	Master File/Header
Service Period	Date Report Is Run
Address	Master File
Meter Number	Master File
Type Utility	Master File
Actual Usage	Meter Card

NOTE: This is a monthly report covering the consumption during the service period. Common usage areas are separately identified because the consumption can't be identified to a unit. Examples of common usage are recreation facilities, community centers, street lighting, etc. A summary of total consumption for each type of utility is necessary.

ENERGY CONSUMPTION BY MASTER METER

Activity Name ______________________

Activity UIC ________________

Service Period ___________

Address	Meter Number	Type Utility	Actual Usage

ENERGY CONSUMPTION BY MASTER METER

DATA ELEMENT	SOURCE
Activity Name	Master File/Header.
Activity UIC	Master File/Header.
Service Period	Date Report Is Run.
Address	Master File.
Meter Number	Master File.
Type Utility	Master File.
Actual Usage	Master Card.

NOTE: This is a monthly report. If master meters are read twice during the month, the total of the two readings will be reported.

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FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
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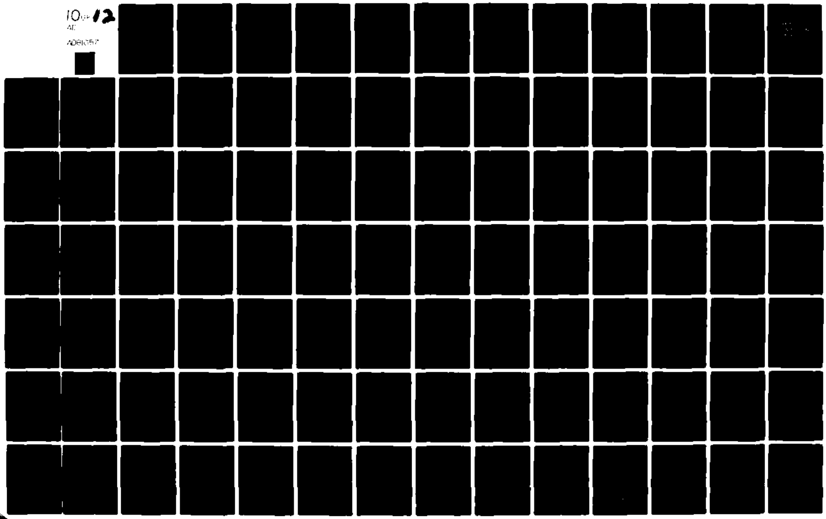

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name __________
Activity UIC __________
Date of Report __________

Category of Quarters	Type of Utility	Usage	Service Period: 1st Period	2nd Period	3rd Period	1st Quarter Total
—	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Gas (CCF)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Oil (Gal)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ____________________
Activity UIC ____________________
Date of Report ____________________

Category of Quarters	Type of Utility	Usage	Service Period: 1st Period	2nd Period	3rd Period	1st Quarter Total
Total Unit Consumption						
	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Gas (CCF)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Oil (Gal)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
Total Common Usage Consumption						
	Electricity (KWH)	Actual Usage				
	Gas (Gal)	Actual Usage				

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ____________
Activity UIC ____________
Date of Report ____________

Category of Quarters	Type of Utility	Usage	Service Period 4th Period	5th Period	6th Period	2nd Quarter Total
—	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Gas (CCF)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Oil (Gal)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ____________
Activity UIC ____________
Date of Report ____________

Category of Quarters	Type of Utility	Usage	Service Period: 4th Period	5th Period	6th Period	2nd Quarter Total
Total Unit Consumption						
	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Gas (CCF)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Oil (Gal)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
Total Common Usage Consumption						
	Electricity Actual Usage (KWH)					
	Gas Actual Usage (Gal)					

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ____________
Activity UIC ____________
Date of Report ____________

Category of Quarters	Type of Utility	Usage	Service Period 7th Period	8th Period	9th Period	3rd Quarter Total
—	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Gas (CCF)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
—	Oil (Gal)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ____________
Activity UIC ____________
Date of Report ____________

Category of Quarters	Type of Utility	Usage	Service Period: 7th Period	8th Period	9th Period	3rd Quarter Total
Total Unit Consumption						
	Electricity (KWH)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Gas (CCF)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
	Oil (Gal)	Actual Occupied				
		Norm Occupied				
		Variance Occupied				
		Actual Vacant				
		Total Usage				
		Occupied Days				
		Vacant Days				
Total Common Usage Consumption						
	Electricity Actual Usage (KWH)					
	Gas Actual Usage (Gal)					

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ______________

Activity UIC ______________

Date of Report ______________

Category of Quarters	Type of Utility	Usage	Service Period 10th Period	11th Period	12th Period	4th Quarter Total	Annual Total
—	Electricity (KWH)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					
—	Gas (CCF)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					
—	Electricity (KWH)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					
—	Oil (Gal)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name ______________
Activity UIC ______________
Date of Report ______________

Category of Quarters	Type of Utility	Usage	Service Period 10th Period	11th Period	12th Period	4th Quarter Total	Annual Total
Total Unit Consumption							
	Electricity (KWH)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					
	Gas (CCF)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					
	Oil (Gal)	Actual Occupied					
		Norm Occupied					
		Variance Occupied					
		Actual Vacant					
		Total Usage					
		Occupied Days					
		Vacant Days					
Total Common Usage Consumption							
	Electricity Actual Usage (KWH)						
	Gas Actual Usage (Gal)						

QUARTERLY ENERGY CONSUMPTION REPORT

Activity Name.	From Master File.
Activity UIC.	From Master File
Date of Report.	Date Report is Run
Category Code.	From Master File. The summary will group consumption by the appropriate category of quarters code which the unit falls into. The category of quarters codes are:

A - Wherry
B - Fund 1970 and After
C - Fund 1950-1969
  1. Capehart
  2. Fund 1950-1969
  3. USA Home
  4. Surplus Commodity
D - Other Public Quarters (OPQ)
  1. Prior 1950
  2. Relocatable
  3. Foreign Source
H - Leased
E - Substandard
  1. Other IPQ
  2. Title III Trailers
  3. Trailers

Type Utility.	From Master File. Type utility will correspond to the appropriate norm code.

Usage.

1. Actual Occupied. From Master File
2. Norm Occupied. From Master File
3. Variance Occupied. Calculation. Actual less norm
4. Actual Vacant. From Master File
5. Total Usage Calculation. Actual Occupied plus Actual Vacant
6. Occupied Days. From Master File
7. Vacant Days. From Master File

NOTE: This report will be printed quarterly with a yearly total on the 4th quarter report. There will be a summary for each type of utility with each category of quarters and also a total of common usage consumption for each period.

OCCUPANT GUIDE TO THE MILITARY FAMILY HOUSING UTILITY BILLING TEST

The Military Family Housing Utility Billing Test was directed by Congress in the FY 1978 Military Construction Authorization Act. The Office of the Secretary of Defense selected your activity, along with nine others, to participate in this one year test. The program includes installing meters for individual units, developing normal energy ceilings (norms), and issuing "mock" bills which you do not pay. As an occupant of military family housing, your cooperation is requested.

The norm for your own unit is calculated using the following information: number of occupants; number of bedrooms; type of construction and insulation materials; daily weather data; and the type of energy used for heating and cooling (if any), cooking, and generating domestic hot water. The norm will change from month to month because of the weather changes and the varying length of the billing periods.

The meters will be read and bills issued monthly. The bill will indicate your total energy consumption, the norm, and the amount which you would have been charged if this were not a test. A detailed explanation of your bill is provided on the reverse of this page.

If there is a balance on line 12, detach both copies of your statement from the return envelope. Fold the second copy in half, put it in the return envelope, and seal the envelope. DO NOT SEND ANY PAYMENT!! When the stub is received, it will be processed as payment in full. If there is no balance due on line 12, no action is required on your part, and we thank you for conserving energy.

Getting into the habit of conserving energy by consuming within the norm will benefit everyone. Your conservation practices will also produce lower utility bills whether you live in government quarters or in the private community. Your cooperation during the test is sincerely appreciated.

HOW TO READ YOUR BILL

LINE:

1. The type of utility and standard unit of measure:

UTILITY	STANDARD UNITS	ABBREVIATION
Electricity	Kilowatt hours	ELC/KWH
Natural Gas	Hundreds of cubic feet	NAG/CCF
Oil	Gallons	OIL/GAL
Steam	Therms (100,000 BTU's)	STM/THM
Hot Water Heat	Therms (100,000 BTU's)	HWH/THM
Liquid Propane Gas	Pounds	LPG/LBS

2&3. If there are two or more meters for the same utility, lines 2 and 3 will indicate the combined reading of all meters for that utility.

4. Usage is expressed in the standard units shown above and is normally the difference between lines 2 and 3. Some meters do not read in the standard units so the difference between lines 2 and 3 is converted to the standard units and shown on line 4.

5. The normal amount of energy required to operate your unit during this billing period (from prior to current reading date).

6. Line 4 minus line 5 equals the amount of usage above the norm. "IN NORM" indicates usage at or below the norm and no charge is computed for that utility.

LINE:

7. Line 4 multiplied by the rate for that utility.

8. Line 5 multiplied by the rate for that utility.

9. Line 6 multiplied by the rate for that utility.

10. Grand total of all excess charges from line 9.

BETWEEN LINE 10 AND 11: If a balance is shown on line 12, a due date will indicate when your billing stub must be returned so that your account can be "credited".

11. A balance here indicates that the stub from the previous bill was not returned on time.

12. Total balance which you would have to pay if this were not a test. IMPORTANT: DO NOT SEND ANY PAYMENT. DURING THIS TEST, RETURNING ONLY THE BILLING STUB IN THE STAMPED, PREADDRESSED ENVELOPE IS CONSIDERED PAYMENT IN FULL.

FOLD LINE

TEAR PERFORATION

DEPARTMENT OF DEFENSE
NAVAL STATION ANYWHERE
HOUSING OFFICE
ANYWHERE, US 99999

POSTAGE AND FEES PAID
OFFICE OF THE SECRETARY OF DEFENSE
DOD 102

U.S. MAIL

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

TO:
DEPARTMENT OF DEFENSE
NAVAL STATION ANYWHERE
HOUSING OFFICE
ANYWHERE, US 99999

PLEASE TEAR ALONG ABOVE PERFORATION AND DISCARD THIS LOWER PORTION BEFORE MAILING

MOISTEN AND FOLD THIS FLAP BACK
BE SURE TO INSERT STUB
TEAR ALONG THIS PERFORATION & KEEP FOR YOUR RECORDS

MILITARY FAMILY HOUSING UTILITY BILLING TEST

Acct.#: 123456-01 Bill Date: 11 MAY 79 Days Billed: 30
Meter Number: 2045 Curr. Read Date: 02 MAY 79 Prior Read Date: 02 APR 79

1. Utility/Measurement	ELC/KWH	NAG/CCF
2. Current Reading	24190	13953
3. Prior Reading	23578	13855
4. Usage	612	98
5. Norm	490	109
6. Variance	122	IN NORM
7. Cost of Total Usage	$24.48	$28.42
8. Cost of Norm	$19.60	$31.61
9. Cost of Excess Usage	$4.88	IN NORM

10. Total Cost of Excess Usage $4.88
PLEASE RETURN BY 01 JUN 79
11. Unpaid Balance $0.00
12. This is a Test. **DO NOT PAY NEW BALANCE OF:** $4.88

RETAIN FOR YOUR RECORDS

NAVFAC UTILITY BILLING SYSTEM STUDY

NAVAL FACILITIES ENGINEERING COMMAND
FACILITIES SYSTEMS OFFICE
NAVAL CONSTRUCTION BATTALION CENTER
PORT HUENEME, CALIFORNIA 93043

ACI ACCX 0677A

UTILITY BILLING SYSTEM STUDY

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UTILITY BILLING SYSTEM STUDY

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UTILITY BILLING SYSTEM STUDY

A. INTRODUCTION

1. Study Overview

The Utility Billing System Study examines methods of implementing a utility billing system for military family housing units in the United States, Guam and Puerto Rico. The billing system would service approximately 310,000 housing units at about 400 activities. With the implementation of the billing system, the actual consumption of energy at each housing unit would be compared to a "normal" usage standard and a bill would be issued to occupants if actual usage exceeded the "normal" usage.

The approach used in the utility billing system study involved three main steps:

a. Research. Research was done to gain information about computer equipment and software available in late 1978. The primary sources used in the research are as follows:

(1) Datapro Directory Software (Volumes 1 and 2) provided a description, along with the cost, of the commercial software packages available for utility billing.

(2) Datapro 70: The EDP Buyer's Bible (Volumes 1 and 2) provided a description, along with the cost, for purchasing hardware.

(3) A General Services Administration (GSA), Region 9, Teleprocessing Services Specialist made available the ADP Resource Catalog, Arizona, Hawaii, California, and Nevada which gave listings of government and commercial ADP sharing sites.

(4) Automatic Data Processing Equipment in the United States Government as of the End of Fiscal Year 1977 proved another source for determining government ADP sharing sites.

(5) A review of technical periodicals published during the last 18 months was especially helpful with regard to the mini-computer market and trends.

(6) Literature for the study of automated meter reading was obtained through attendance at the Pacific Coast Electrical Association 1979 Engineering Conference.

(7) The following volumes of Auerbach Datacomm 80 supplied cost information and descriptions for remote job and data entry equipment, mini-computers, terminals and communication lines:

(a) Distributed Systems: Data Entry Equipment, Software and Data Base Management,

(b) Distributed Systems: Design Information and Network Architecture,

(c) Distributed Systems: Remote Batch Systems, Intelligent Terminal Systems, and

(d) Distributed Systems: Small Business Computers - U.S.

These research materials are referenced in the Bibliography (page 70).

b. Follow-up interviews. Representatives of software package firms and managers of government and commercial ADP time-sharing sites were interviewed:

(1) Software. Upon identifying software options from research materials, further information was collected. Representatives for the following systems were contacted and interviewed:

(a) Bancroft's Multicompany Utility Billing Subsystem,

(b) Burroughs Government Information Systems (BGIS) Utility Billing System,

(c) IBM Utility Billing System,

(d) METERLOG,

(e) TRES Customer Information Service,

(f) City of Melbourne Utility Billing and Accounting Systems, and

(g) Omega Utility Customer Accounting and Information System.

(2) Government and commercial ADP time sharing sites. Managers of the following were interviewed:

(a) Harry Diamond Laboratories,
(b) Lawrence Berkeley Lab,
(c) Rand Corporation,

(d) Rockwell International Aerospace Corporation,
(e) U. S. Geological Survey, and
(f) U. S. Mint San Francisco.

c. Review of the operations of the Family Housing Mock Utility Billing System (FHMUBS). This review proved quite important for two reasons:

(1) To establish guidelines for extending FHMUBS

FHMUBS is a utility billing system already servicing approximately 10,000 military family housing units. Expanding this system could very well be the best solution for a utility billing system.

(2) To establish guidelines for all aspects of the study

The estimation of implementation time for the expansion of system coverage from 10,000 military family housing units to 310,000 could be done reliably. Cost could be better estimated, as well. FHMUBS was implemented using milestone plans which can now be evaluated for areas of success and failure. Successful areas of planning will provide a framework for not only expanding FHMUBS, but, also, for determining the best approach to use, given whatever option. Areas of failure will indicate "what not to do".

Many problem areas have been encountered and resolved. For example, an indirect metering system has to be used in Great Lakes, Illinois, in what became known as the master/slave metering system. As many as 15 units share a single gas fired water heater. A single gas meter, called the master meter, measures total gas consumed by all units for heating water. Each unit has a hot water meter, called a slave meter, which measures hot water for each unit. These slave meter readings can be added to give total hot water "consumed." Conversions can be made to use the hot water consumption to determine the gas usage for each. Also, estimations of meter readings had to be done in Great Lakes, when meters were covered with snow and could not be read by meter readers, and in Beaufort, South Carolina, meters ran backwards due to incorrect meter installation so usage had to be estimated for that period of time.

This sampling of special problems, along with others encountered throughout the FHMUBS implementation and production periods, gave an indication of what a full scale implementation will involve. With certainty, extending system coverage from 10,000 to 310,000 housing units will bring new problems. The utility billing system must be flexible enough to allow for the incorporation of solutions to new problems.

2. System Requirements

The utility billing system selected must perform the following major functions:

a. Measure consumption of all types of energy consumed in military family housing units, such as electricity, gas, oil, and liquid propane gas (LPG). Standard and nonstandard units of measure must be accommodated.

b. Accommodate different billing rates for the same utility at an activity.

c. Edit input data to the maximum extent possible and maintain error suspense/control.

d. Use daily weather information, physical and thermodynamic properties of housing units and occupancy data to generate a norm.

e. Compute charges for actual energy consumption and for consumption in excess of the norm.

f. Generate one utility bill for each housing unit.

g. Produce meter reading documents.

h. Interface to an accounts receivable system.

i. Retain historical data on actual consumption, norm consumption and revenue.

j. Provide for file maintenance of all data elements on all data files, i. e., provide for updating/correcting utility bills and the issue of corrected utility bills.

k. Produce the required management reports.

l. Segregate utility bills and local reports by installation.

m. Conform to the provisions of the Privacy Act of 1974.

n. Accommodate flexible billing schedules.

3. Issues

The two data processing modes, batch and interactive, are important components in both the hardware and data acquisition paragraphs of this study. Batch processing accumulates a certain amount of data from keypunched cards, tapes, or diskettes which is held on disks or tapes before the entire "batch" is transmitted to the computer for processing. Output from the computer is dispatched in a similar manner, large batches. The interactive mode by-passes punched cards, tapes or diskettes and, via a terminal, document information is immediately transmitted to a host computer. The data is then edited and results sent back to a screen on the terminal. Files can be updated immediately and there is a sense of interaction between the host computer and the terminal.

There were three key elements which were of prime importance in the evaluation of the alternatives for the utility billing system:

a. Hardware configuration - computers, disks, tapes, printers, and communications equipment. There were several possibilities for the hardware configuration:

(1) A single large mainframe which receives data from all activities. Data can be transmitted from the activities to the processing site via any one of several methods discussed in the data acquisition paragraph. The processing could only be batch. Due to the high volume of transactions (a projected 1,550,000 transactions per month based on experience with FHMUBS). FHMUBS uses a large mainframe located at Harry Diamond Laboratories, a government time-sharing facility. Data is processed in a batch mode.

(2) Three medium or large mainframes, one for each branch of service. Navy and the Marine Corps, Army, and Air Force would each have a mainframe for processing work for their respective billing systems. Processing in the multiple mainframe case could be either batch or interactive.

(3) Several medium or large computers located on some regional basis. For example, activities in one time zone could be called a region and there would be a medium or large computer which would receive the data transmitted from all activities in that time zone. In the case of regions based on time zone, there would be four regions each with a medium or large mainframe. Processing could be batch or interactive depending on the capability desired.

(4) A mini-computer at each of the largest activities with a medium or large mainframe for management reporting for all activities. Meter readers at the activity would enter data into the mini-computer located at or near the activity. Mini-computer processing could be batch or interactive. However, capital outlay for purchasing mini-computers usually is done to gain the interactive capability. Processing for management reporting would probably be in the batch mode on the mainframe.

b. Software support - computer programs and computer operations procedures. Options for software are:

(1) The existing software for FHMUBS could be expanded and modified.

(2) A commercial software package could be purchased and modified.

(3) New software could be developed.

c. Data acquisition - the process of collecting data, recording the data, transcribing data to a machine-readable format for use in processing, and transmitting this data to the computer site. There would be many peripheral arrangements which could be used and these will be presented in the data acquisition paragraphs beginning on page 14.

These three key elements provided the basis for the alternatives presented. Various combinations within the spectrum of hardware configuration, software support and data acquisition were examined to prepare the four alternatives presented in this study.

4. Selection Criteria

Criteria by which alternatives for the utility billing system were judged are:

a. Cost. The 8 year system life cost of the computer system as developed using SECNAVINST 5236.1A: Specification, Selection, and Acquisition of Automatic Data Processing Equipment and NAVFAC Economic Analysis Handbook as guidelines.

b. Responsiveness. Responsiveness was determined by how fast data adjustments could be made and data could be transmitted to the computer site, as well as reporting turnaround time.

c. Reliability. Reliability of the system was determined by the ability of the system to function without failure and by the amount of credence which could be placed in the results.

d. Implementation time. Implementation time generally would take 20% to 50% of the total 8 year system life time. Implementation time is the time necessary to complete the following tasks: let contracts, modify or develop software, train users and operations personnel, and load initial data. Near the end of the implementation period as users are trained for two weeks and return to their activities, three months are allowed to handle the initial data load. After the data is loaded for each activity, that activity begins production without waiting for all the other activities to finish training and loading data. For this reason, one part of implementation (training and loading data processes) for some activities will overlap with another (reading meters and sending a "mock" bill) for others. This is what is termed "phased implementation".

e. System flexibility. Flexibility would be the ability of the software and hardware to process greater volumes of data, as needed, and the ability to handle rule changes quickly and easily with a certain degree of flexibility.

Applying this selection criteria to the key elements (A3, page 5) should provide a system which would best fit the needs of the Defense Family Housing Metering System.

B. REVIEW OF KEY ELEMENTS

1. <u>Hardware</u>

To handle 310,000 accounts (90,000 Navy and Marine, 95,000 Army, and 125,000 Air Force) the hardware option must satisfy the following requirements:

Approximately 960 megabytes of mass storage,

Approximately 29 hours per month of CPU time or 800 hours of wall clock time (both these figures were based on an IBM 370/168 and on the capability it has of running many jobs at the same time through partitioning available on this computer), and

Approximately 21.9 million lines of print per month.

Approximately 30 tapes per month for back-up of the system.

See Cost and Calculation, reference F2a, page 40. For requirements in the case of three mainframes and the mini-computer, see Cost and Calculations references F2b and F2c, page 43.

It was recognized that there would be changes both in the surplus capacity on the government computers and in the availability of commercial computers within the period between the study and any implementation of a new system. Also it is known that various changes would occur in machine design and capabilities. However, except where noted, today's hardware capabilities were assumed.

a. Mainframes. The hardware configuration required for a central computer facility or for a few regional computer facilities would be similar, except that smaller machines could be used in a regional processing arrangement. From a review of the ADPE in the United States Government as of the End of Fiscal Year 1977, it was seen that many potential government sites exist on which to place this system load. Two hundred six IBM computers were found in the listings, not to mention other manufacturers', which could be candidates. Conversation with several representatives of computer sites suggested that finding one or several host computers would not be difficult. In addition, several commercial sites were seen to have sufficient capacity. Projected costs for acquiring and maintaining the needed equipment along with operational expenses were developed and are presented in TABLE 1.

TABLE 1

Mainframe Hardware Cost Options
(Using 1978 Dollars, in Thousands)

Option	Purchase Cost	Annual Expense	Total Net Present Value (NPV)	COST REF
Purchasing:				
Single	$3,066	$3,889	$24,844	F3a
Multiple (by Service)	$1,842	$4,511	$27,104	F3b
Time-Sharing:				
Single Government	-	$4,004	$22,422	F3c
Multiple Government (by Service)	-	$4,201	$23,526	F3d
Single Commercial	-	$4,188	$23,453	F3e

It should be noted that all of the above were developed using mail service for transmitting data. Alternative 2 presented in paragraph E is the above Multiple Government (Time-Sharing) approach except that RJE stations are used in costing. (The mail approach to data transmission is not feasible for the actual implementation of the billing system due to the poor response the mail would be able to give to this customer oriented system. However, for cost comparison purposes it was used above.)

In general, buying new hardware would entail additional personnel and hardware expense without corresponding benefits under the conditions foreseen.

Also, it can be noted that the use of commercial time-sharing was generally found to be more expensive than the use of government time-sharing in the case of CPU charges. It was found that time-sharing at multiple sites (three sites) provides a cost advantage derived from reduced overtime costs. There would be non-cost advantages for using multiple mainframes by service so that the inter-service coordination effort would be minimized. Dividing the total workload of the billing system by service will be considered in both alternatives.

Assuming Federal Telecommunications System (FTS) communication lines could be used for transmission of data (FTS charges are on a flat rate basis regardless of distance), locating multiple mainframes by time zone would not offer any telecommuncation cost saving compared to randomly positioned mainframes with RJE so this was not pursued for an alternative.

b. Mini-Computers. The hardware requirements for mini-computers were estimated and based upon the following assumptions:

(1) To qualify for a mini-computer system, an activity would need 500 or more housing units. Using housing inventories contained in the April 1978 DD1410 compilation, it was determined that 168 mini-computers would be needed. TABLE 14 on page 57 gives a break down by service of the mini-computers. It should be noted that the 168 will be used for the 168 sites, but there will be six more machines for software development and maintenance giving a total of 174 mini-computers for costing purposes. A small variation could be expected as a result of inaccuracies in the inventory or changes which have occurred over time. Further modest adjustments might be made if clusters of activities were to share a single mini-computer.

(2) Mail service could be used for transmission of summary data from the activities to a mainframe site.

(3) Some minimal use of interactive terminals at nearby activities would occur. Activities in the local telephone area, with too few accounts to justify their own mini-computer, might have an interactive terminal for file update and inquiry.

The mini-computer system chosen to base costs upon was a PDP 11/23. Although 1978 costs were used for equipment and other cost variables in all other cases, 1979 mini-computer equipment was selected. This selection was made in order to realistically present the mini-computer alternative. In no other area did research indicate such a radical change in cost and machine capability. TABLE 2 below gives an estimation for equipment purchase and yearly production costs involved for implementing the billing system using 174 mini-computers.

TABLE 2

Mini-computer Hardware Cost Option
(Using 1978 dollars, in thousands)

Purchase Cost	Annual Expense	Total Net Present Value (NPV)	Cost Ref
$8,653	$3,184	$26,483	F3f

(See Cost and Calculation, reference F3f, page 55.)

The PDP 11/23 was chosen as representative of a class of small business computers. It was felt to be an adequate choice based upon its CPU, peripherals and operating system software.

Depending upon how long it takes to implement the billing system, the mini-computer alternative may become far better competition for the large mainframe computer. Currently in the hobby or personal computer market there are systems selling for between $8,000 and $15,000 with the hardware capabilities equivalent to the above system at an average cost for 174 machines of approximately $50,000. When these systems mature and the surviving companies become stronger, very inexpensive systems will probably be available. At present these offerings characteristically suffer from lack of maintenance support, incompletely-tested software, and inflexible hardware.

2. Software

The best software offerings that this research and study could identify are:

a. EFHMUBS - Extended Family Housing Mock Utility Billing System. FHMUBS could be expanded and deficiencies which have been found could be corrected. This software approach would work well in the case of medium or large mainframe hardware configurations with batch processing since FHMUBS operates in that environment. FHMUBS would require the least amount of modification and would be ready for production soonest. It was estimated that it would take approximately 15 months for the enhancement of FHMUBS at a cost of approximately $1,151,000 (see Cost and Calculations, reference F4a, page 58).

The EFHMUBS alternative would have several advantages:

relative low cost,

availability in a comparatively short time,

close adherence to Federal Information Processing Standards (FIPS) which makes it transportable from one computer to another, and

reliability due to a year long test.

b. Commercial Software Packages. There are many utility billing software packages available. Many of the packages are oriented to mini-computers. These commercial software offerings would require modification to meet the needs of the utility billing system.

Three software packages are presented in the study:

(1) Customer Information System (CIS) (TRES Computer Systems, Inc.; One Lemmon Park Midway; 4255 LBJ Freeway; Dallas, Texas 75234; 214-233-4341). CIS is a utility billing system oriented to a large mainframe computer using batch or interactive processing. TRES's software product is being used throughout the United States and has been on the market since 1971. TRES is one of the few established software houses which deals in marketing and servicing a utility billing system. The purchase price for the license would be $95,000 for the CIS Batch System. To gain the interactive capability, an Inquiry Module and an Order Entry Module would be needed and their cost would be an additional $70,000. These costs are one time costs and include documentation and source listings.

(2) Multicompany Utility Billing Subsystem. (Bancroft Computer Systems; P. O. Box 1533; West Monroe, Louisiana 71291; 318-388-2236). The Bancroft Multicompany Utility Billing Subsystem is designed primarily for the IBM System 3. As delivered, the system will operate on an IBM System 3, Model 10 Disk with Multi-Function Card Unit, 132 Print Position Printer and 16K storage. The programming language is RPG-II. The Multicompany Utility Billing Subsystem must be used in conjunction with the Multicompany Balance Forward Accounts Receivable system. The two together would cost $3,340 for the license which would cost a total of $581,160 for use with 174 machines.

(3) Burroughs Government Information Systems (BGIS) Utility Billing System (Burroughs Corporation; Burroughs Place; Detroit, Michigan 48232). The Burroughs software package is designed to be used on a Burroughs mini-computer, B800 or B80, for 20,000 accounts or less. The programming language is COBOL. The system was also designed to be flexible using a matrix table for establishing user requirements, such as the energy sources to be measured, the desired rates, etc. Burroughs has a discount pricing policy available for volume purchasing and a governmental team whose main concern is handling government programs. The license fee would be paid by a one-time $3,500 per machine cost. To obtain the software for 174 mini-computers it would cost $609,000. This is for the batch processing mode. Relatively new to the market is an interactive version which would cost $4,540 per mini-computer or $789,960 for 174 mini-computers. If the Burroughs software is desired, the

Burroughs hardware would be a necessary feature. The Burroughs software package is a good example of the many utility billing systems which are available, but relative to the specific hardware manufacturer. The software would be interchangeable among Burroughs models so that activities which are small or large could purchase the model best suited to the volume of work at those activities.

The cost for the modification of the commercial software packages was developed in the Cost and Calculation, reference F4b, page 59, and was assumed the same for whatever software was selected. The approximate cost would be $1,622,000 over a period of 18 months. To arrive at a final cost for a commerical software package, it would be necessary to add the licensing fee to the projected modification expense.

The functions performed by FHMUBS and by the commercial software offerings were compared to the system requirements. The results of the comparison can be found in TABLE 3, page 13. For the purpose of comparing cost, TABLE 4, page 14, can be used.

c. Development of New Software. Software can be developed beginning with the system definition phase, through completely designing, programming and documenting a system tailored to the exact requirement of an extended FHMUBS. Software could be developed for three types of computer systems:

large mainframe, batch,
large mainframe, interactive, and,
mini-computer, interactive.

Since FHMUBS has been field tested and is a batch, large mainframe-based system, it would prove redundant and expensive to develop a new software package for such a system. Also, in the case of the large mainframe, interactive system, it would not be feasible to develop a new software system which would be able to handle this volume and distribution of users, technically or economically. Therefore, for development of a new software package, only interactive mini-computer systems will be considered. Such a system would be expected to be the most responsive. It would also provide additional tools to lessen the work required to process and monitor data. System reliability probably would compare unfavorably with the other alternatives at first, since this new system would not have been field tested. However, after an initial period of review, no system reliability differences would be apparent.

The cost for developing new software can be referenced in paragraph F4c on page 59. It was estimated that total cost for software development would be $2,126,000 which proves to be less than the estimated purchase price of commercial software and cost for modifying it.

d. Software Comparisons. Each of these software options (with the exception of new development) are compared against the major functional requirements of the system in the following table.

TABLE 3

Software Options Compared to System Requirements

	FHMUBS	TRES	BANCROFT	BURROUGHS
Measure consumption of all types of energy such as electricity, gas, oil, steam, liquid propane gas (LPG) and hot water. Standard and non-units of measure must be accommodated.	X	X	X	X
Accommodate different billing rates for the same utility at an activity.		X	X	X
Edit input data to the maximum extent possible and maintain error suspense/control.		X		
Use daily weather information, physical and thermodynamic properties of housing units and occupancy data to generate a norm.	X			
Compute charges for actual energy consumption and for consumption in excess of the norm.	X			
Generate one utility bill for each housing unit.	X	X	X	X
Produce meter reading documents.	X	X		
Interface to an accounts receivable system.				
Retain historical data on actual consumption, norm consumption and revenue.	X			
Provide for file maintenance of all data elements on all data files, i. e., provide for updating/correction utility bills and the issue of corrected utility bills.		X		
Produce the required management reports.	X			
Segregate utility bills and local reports by installation.	X	X	X	X
Conform to the provisions of the Privacy Act.	X			
Accommodate flexible billing schedules.	X	X	X	X

TABLE 4 which follows next will compare time and cost of software:

TABLE 4

Estimated Software Cost
(Using 1978 dollars, in thousands)

	Expected Time	License Fee	Modification Cost	Total
EFHMUBS				
Mainframe	15 months	---	$1,351	$1,351
TRES				
Mainframe	18 months	$ 95	1,622	1,717
Bancroft				
Mini-computer	18 months	581	1,622	2,203
Burroughs				
Mini-computer	18 months	790	1,622	2,412
New development				
Mini-computer	24 months	---	2,126	2,126

(See Cost & Calculation, reference F4, page 58.)

3. Data Acquisition

Data acquisition involves the gathering of raw data, recording the data, transmitting this recorded data to the computer site and transcribing data to a machine readable format for processing. Data may enter the computer for processing either via batch mode or interactive mode. Each step of data acquisition will be studied to provide a survey of possibilities and requirements for the utility billing system.

a. Collecting Data. The data to be collected is as follows:

(1) Building survey information. This data gives the structural and thermodynamic details for each housing unit which are used in "norm" calculations.

(2) Weather information. Air and water temperature would be measured on a daily basis and used in "norm" calculations.

(3) Occupant information. Data relating to the occupant of the housing unit would be used in billing, in record keeping, and in "norm" calculations.

(4) Check-in information. Data in this case actually starts responsibility for billing and releases it as occupants move in and out of the housing unit.

(5) Meter information. Physical location and serial number of the meter would be provided along with route number and reading sequence.

(6) Meter reading information. At a regular time interval, the usage of energy would be determined through these meter readings.

b. Recording Data. Data could be recorded on pre-printed forms. In the prototype, FHMUBS, six types of initial forms were needed for each housing unit along with additional forms for changes. It was estimated that 2.2 million forms would be needed for implementation and 8.5 million forms for production costing $47,000 and $287,000, respectively (see Cost and Calculation reference F7c(2) and F3c(4), pages 65 and 45, respectively). In the case of METERLOG and remote meter reading, meter readings would not be recorded on forms. The METERLOG and remote meter reading systems will be discussed under Special Cases.

c. Transcribing Data. After the data has been recorded on the pre-printed forms, it must be keyed into a machine-readable format for processing.

In the case of batch processing, the keying can be done in one of two ways. The data could be punched onto cards by keypunchers. If not keyed to card, the data could be keyed to a magnetic device, either a tape or diskette, in a similar manner. In the case of interactive processing, this step is <u>not</u> necessary because an operator at a computer terminal would enter the pre-printed form data directly to the computer.

Both processes of keying include a verification process which provides a double check of the original keying. Keypunch work is verified by keypunching over the already punched information and if there is any discrepancy, a light will register and the data must be corrected. On card input, only 1 space out of the 80 spaces may be incorrect, but the entire card must be retyped for proper verification. On tapes or diskettes, the error can be adjusted without redoing all the data.

To key data to card would require a staff of seventy-nine people. The required staff would include:

1 Data Entry Manager,
2 Data Entry Supervisors,
33 Keypunch Operators, and
33 Verifiers.

The cost of staffing for keying to card for a production year was developed in Cost and Calculations, reference F5a, page 60. An estimated cost of $1,250,000 was determined.

In the case of keying data to a magnetic device, an annual staffing would include:

1 Data Entry Manager,
2 Data Entry Supervisors,
29 Keypunch Operators, and
29 Verifiers.

The reduction in work force as compared to the key to card staffing is due to the higher keystroke rate of 11,385 keystrokes per hour which is due to improved machine efficiency. The cost for staffing for a production year for keying to a magnetic device was developed in Cost and Calculations, reference F5b, page 61. An estimated cost of $1,098,000 was calculated.

The cost of contracting for keying the data is close to the in-house staffing cost for the service. The estimated annual production cost was $1,625,000 for keying to card and $1,393,000 for keying to magnetic device (see Cost and Calculation reference F5c and F5d, page 61).

TABLE 5 compares staffing and contract costs for keying data to card or to a magnetic device.

TABLE 5

Estimated Cost for Transcribing Data for a Production Year
(Using 1978 dollars, in thousands)

	In-House Staffing	Contract Cost
Key to card	$1,250	$1,625
Key to magnetic device	1,098	1,393

(See Cost and Calculations, reference F5, page 60.)

Since cost was close and could vary depending on the assumptions used, the decision to use the contract approach for data entry throughout the costing paragraphs of the study was made for two reasons:

(1) There is a current ceiling on hiring new Civil Service employees, and

(2) The trend is to shift the data entry function from "in house" to contract.

d. Transmitting Data. Transmitting the data to the computer which will then process it is the next step in data acquisition. There are two main possibilities for data transmission: mail service and telecommunications.

(1) Mail Service. In the case of mail service, the data acquistion steps could follow any one of the two flow patterns described below:

(a) Pre-printed forms are mailed to the central site. The data is recorded on pre-printed forms and these forms are mailed to the central site area for keying. The keyed data (cards, tapes, or diskettes) is fed into the computer where it is stored for the time a "batch" is ready to run.

(b) Keyed data (cards, tapes, or diskettes) is mailed to the central site. The data is recorded on pre-printed forms and keyed near the activity site. This keyed data is mailed to the computer site and fed into the computer where the data is stored until a "batch" is ready to run.

Before continuing with telecommunications methods of transmitting data, cost for mailing will be considered. The U.S. Mail Service was compared cost-wise to parcel post, commercial couriers, air freight, and communication lines. The U.S. Mail Service proved the cheapest means of transmitting data and communication lines proved the fastest. It was estimated that annual production mailing costs would be $606,000 (see Cost and Calculation, reference F3a(2)(f), page 47). However, the mail solution for transmitting data is used only in cost comparisons. Neither of the selected alternatives use the U. S. Mail Service for transmitting data because the responsiveness and flexibility desired could not be achieved with a billing system which relied on the Mail Service for data transmission. The $.15 per bill per billing cycle for the 310,000 bills is the mail cost for the alternatives and this amounts to $558,000 on a yearly basis.

(2) Telecommunications. Again, as in the case of the U.S. Mail Service, the data acquisition procedure could follow one of two routes:

(a) Interactive. The data on the pre-printed forms is entered into the local mini-computer or the mainframe (in the case of multiple or regional mainframe) via a keyboard on a cathode ray tube

(CRT) screen. The data is then edited and the result is displayed on the screen for verification. Summary data from the local mini-computer site would be sent through mail service or telecommunication lines to a central site for batch processing.

Using the DEC PDP 11/23 (Data System 350) as a costing mini-computer model which has the interactive capability, the cost per unit would be approximately $50,000. The cost for purchasing 174 mini-computers would be $8,700,000 plus monthly maintenance of $270 per unit; annually for all mini-computer sites, the maintenance cost would be $564,840 (see Cost and Calculations, reference F3f(1) and F3f(2)(a), pages 55 and 57). The use of remote interactive peripherals was not investigated so cost figures will not be presented.

(b) Remote Job Entry (RJE). The data is recorded on pre-printed forms, keyed near the activity site, transmitted via telecommunication lines to the computer where it is stored until time for processing.

The equipment used for RJE would be a terminal controller, operator console, line printer, card reader, and a modem. Using the IBM 3770/3777 as a model, the equipment cost per site would be approximately $54,000. The one time cost for purchasing the RJE equipment for 174 machines would be about $9,396,000. (See Cost and Calculations, reference F8a(1)(a), page 66.) The monthly maintenance cost would be approximately $435 per site; annually for all RJE sites, the maintenance cost would be about $1,892,000.

Telecommunication cost for data transmission are higher than those for mail service, but these costs must be evaluated in terms of better response and reliability.

e. Special Cases. There are meter reading techniques which could handle part of the acquisition of data. METERLOG and remote meter reading will be discussed in this paragraph.

(1) METERLOG is a hand-held data collection system which provides a direct link from the field to the computer. The meter data is entered on the keyboard of a METERLOG, verified automatically and stored in a semi-conductor memory. At the end of the route, the data is transmitted via telephone lines, to the computer for immediate processing. With METERLOG, use of pre-printed forms would be at a

minimum and data transcription (coding) is unnecessary. The price is approximately $2,500 per unit.

(2) Remote meter reading is another way to record and transcribe data. The meters are read through use of telephone lines, power lines or radio systems.

(a) Telephone Lines. The Pacific Telephone and Telegraph (PT&T) Company and Southern California Edison (SCE) Company are jointly implementing a pilot system using telephone facilities as the link between the utility company and the residential customer premises. Control Device Limited of Alberta, Canada, developed the system. The hardware is located at the telephone office closest to the area it is serving. The same telephone is used as the customer uses for day-to-day service. One system could service 368,000 customers. If someone does not subscribe to a telephone, a transponder can be used.

(b) Powerlines. Rockwell International has a system which uses power lines as carriers for remote meter readings. This method has the capability of reading up to three types of meters per dwelling. There is a system capacity of 500 sub-stations, 1.9 million customer sites. The system was designed for reliable collection of data at a centralized location. In addition to automatic meter reading, an interface to utility billing system is available.

(c) Radio Systems. Motorola has a system that utilizes a radio receiver to receive remote meter readings. The system would provide for automatically reading meters and billing customers from a remote site by transmitting meter data via a microwave radio system.

It should be noted that all three of the above automatic meter reading systems have the following in common:

Existing meters may be used with slight modifications.

Any type of energy may be measured.

All systems for automatic meter reading are in the pilot stage.

Cost estimates to implement will not be available until pilot stages are completed.

Meter tampering and meter malfunction are monitored.

At present, these systems are only available as a by-product of load management.

Accuracy of data is increased because the human element of meter reading is eliminated.

4. Concluding Remarks

a. *Norm. The "normal"* usage for each utility for each housing unit is called the norm and it is derived from building survey, occupant, and weather information. The Building Loads Analysis System Thermodynamics (BLAST) software package was used for the prototype FHMUBS to determine heating and cooling factors from building survey information for each unit. When these factors are combined with occupant and weather information in calculations, a "normal" or norm usage for each energy used for each housing unit is given.

The norm calculations have effect on both implementation and production costs. In both cases, the main effect is on forms, data entry, and mailing (using the least cost option for data transmission for purposes of discussion) costs: $206,000 of these three costs for implementation and $24,000 for production (reference F6a(1) and F6a(2), pages 61 and 62). The small impact of .9% of the total computer time for generating norms for the system was so nominal that the costs were not included in comparisons. If the norm were eliminated, some of the cost to modify a commercial billing software package would be saved since the norm is unique to FHMUBS.

b. Utility Companies. Turning over system responsibilities to utility companies was not considered a feasible alternative because of the following:

(1) Hundreds of utility companies would be involved since on the average each housing unit has at least two sources of energy, for example gas and electricity. Each utility company would have to agree to generate norms or accept credit for norms.

(2) Modifications in the existing housing units powerlines, meters, etc., would be needed to meet a variety of utility company standards.

c. Summary. In conclusion, the following key elements were discussed in these paragraphs: hardware, software, and data acquisition. The hardware options reviewed were: to purchase a large mainframe computer, to lease time from government computer sites, to lease time from commercial computer sites, and to purchase mini-computers. The software options included the purchase of a commercial software utility billing package, the extension of the prototype FHMUBS utility billing software, and the development of a new utility billing package. The data acquisition options reviewed were methods of gathering, transmitting, transcribing, and processing data. Data could be gathered by use of forms, METERLOG or remote reading. Data could be transmitted by courier, communication or power lines, or by radio signals. Data could be transcribed by keying to card or magnetic device, by METERLOG, by keying on terminals, or by a remote process. Data could be processed in an interactive or batch mode.

Hardware, software, and data acquisition options were grouped to form the alternatives presented in the following paragraphs of the study:

Alternative 1 is a utility billing system using purchased mini-computers which would be placed at sites with 500 or more housing units. Software would be developed for the mini-computer. Data would be gathered on forms, and transmitted to the computer in an interactive mode using cathode ray tube (CRT) screen terminals. Remote sites would use mail services for transmitting data. The annual production cost for Alternative 1 would be approximately $3,184,000.

Alternative 2 is a utility billing system using leased time on three existing government computers (one for Navy and the Marine Corps, one for Army, and one for Air Force processing) with EFHMUBS as the software package. Data would be gathered on forms which would be sent out to an area data entry contractor for keying. After the data is keyed, it is transmitted via telecommunication lines and RJE equipment to the appropriate computer center and processed in a batch mode. The annual production cost for Alternative 2 was estimated to be $6,201,000.

Due to the ceiling on hiring for Civil Service employees, use of contractors was assumed, unless otherwise noted, in the alternatives for data entry, programming and operations.

TABLE 6 presents a total system life cost for each alternative, as well as the cost per housing unit.

TABLE 6

Comparison of Alternatives
(Using 1978 dollars, in thousands)

	Implementation Time	Net Present Value (in thousands)	Cost Per Housing Unit
Alternative 1	50 Months	$38,291	$124
Alternative 2	40 Months	54,482	176

C. RECOMMENDED ALTERNATIVE

As originally stated the cost, responsiveness, reliability, implementation time, and system flexibility were the criteria for judging each of the key elements for a billing system: hardware, software, and data acquisition. A brief description of each alternative is given in the summary (B4c, page 21) and a detailed discussion of each alternative will follow in D and E. Each of the two alternatives has a major emphasis which can be briefly stated as follows:

Alternative 1 - Responsiveness, mini-computers
Alternative 2 - Responsiveness, mainframes

Alternative 2 (using three mainframes, batch processing, and RJE) would provide each service the opportunity of structuring a billing system independent of the other branches of service, but so will Alternative 1 (using mini-computers and interactive processing). It was determined that each service should be responsible for that service's billing system as this would minimize inter-service coordination efforts. For structuring the alternatives, a headquarters group for service project managers and analysts could work together to coordinate the over-all effort. As will be seen in the discussion of Alternative 2, RJE stations will provide the responsiveness mail service approaches cannot, but there will be a need to provide for security problems which could result without safeguards. Alternative 2 would be the most costly of the two alternatives, even if already existing equipment were used.

Alternative 1 (using mini-computers and interactive processing) provides the lowest cost for a very responsive system. The mini-computer market is changing rapidly so it is known that within the time reference for the implementing of the utility billing system, the mini-computer selected for cost estimating for the study may not be the best choice for the system. However, since the technological changes are improving the mini-computer hardware and the market shows the costs moving downward, it can be noted that the cost for the mini-computer alternative should only lessen with time. The same downward cost trend has not been noticed for the RJE stations, which provide the next best response at any kind of reasonable price, although at the time of implementing the utility billing system, all costs should be re-evaluated. The mini-computer provides physical control over system security for each site, as well as, excellent response for the user. The cost worked out to be cheaper than Alternative 1. Although, mailing or courier service was assumed in Alternative 1 for nearby sites, it is quite possible to add telecommunications to the mini-computer at the larger site whenever a network looked like it could be developed so that even better data reliability could be achieved.

D. ALTERNATIVE 1 - MINI-COMPUTERS, INTERACTIVE

1. Emphasis. Alternative 1 presents the utility billing system most responsive to user needs, providing control at the user level.

2. Description. Alternative 2 would be an interactive, mini-computer approach which would use software developed by each branch of service according to the needs of each service.

a. Hardware Support. A single procurement of computer hardware would provide a family of mini-computers with variations possible in peripherals and communications. Mini-computers would be placed at approximately 168 sites which have 500 or more accounts. These sites would share their resources with activities that have less than 500 accounts. There would be over 200 activities that would not be large enough to have a mini-computer so these sites would communicate by mail service or telephone lines. The communication method would be dependent on the number of accounts at the site and the geographical location. Also required for management reporting would be three mainframes at existing government data processing time-sharing facilities designated by each branch of service. One brance of service would be responsible for rolled-up reports to OSD.

b. Software Support. Software would be developed in BASIC, COBOL, or DOD1. programs and operating procedures would be developed by each service to fit individual needs.

c. Procedure

(1) Implementation. Personnel at activities would complete initial data forms. Three data entry contracts would be obtained to perform data transcription for the initial load. The completed initial data forms would be batched and mailed to the data transcription facilities where the data would be keyed and verified. The output tapes would be sent back to the activities for processing through the mini-computer. Initial load data would be reviewed at the activity by housing office personnel.

(2) Production. Personnel at the activities would be responsible for updating files. Entry of weather and data adjustments could be performed daily. Meter reading data would be entered into the mini-computer on some schedule to be determined by the activity. Each activity could also determine a billing schedule. Output would be reviewed and errors corrected on the same day. Billing registers would either be transmitted to the appropriate accounting offices in a machine-readable format or on print-outs, or made available on interactive terminals. The accounting offices would provide receipt data to the utility billing system in a similar manner. Data would then be sent from each activity to the appropriate one of three main computer sites for system-wide management reports.

3. <u>Assumptions and Constraints</u>

a. Project managers would wait for data tapes to be mailed to the main computer on a monthly basis from the billing site and processed before receiving management reports.

b. Phased implementation would be acceptable. Larger activities would be implemented first. Sites with fewer than 500 accounts would be implemented last.

c. Specifics on accounting interfaces have yet to be determined, but existing accounting systems would be used. Each service would make this determination to suite the particular needs of that service.

4. <u>Advantages</u>

a. High Data Reliability. The correction process could be started as soon as the results are received so much credence could be placed in the results. After the system was thoroughly tested, reliability based on the system functioning without error would increase.

b. Very Responsive. The input would be edited and output be received in a short time span. With the computer at the billing site, there would be an ability to quickly answer customer and user questions. Customer and user morale would be improved due to the good reliability and responsiveness of this alternative. Management reports would be current and accurate due to current file status.

c. Flexibility. Hardware could be installed or removed easily from sites as required. If the volume of the site's work load was changed, adjustments could readily be made. A CRT screen or disk unit could be added or relocated depending on the requirements changes at the activity level.

5. <u>Disadvantages</u>

b. System Integrity Risks. There are two factors which increase risks to the system. Security could be difficult to maintain because of diffusion of processing to 168 sites. Software could also be more difficult to maintain for the same reason. These risks can be seen as potentially effecting system reliability.

c. Implementation Time. Because both new hardware is procured and new software developed, implementation time is expected to be 10 month longer than Alternative 2.

6. <u>Implementation Schedule</u>

a. Each branch of service lets contracts for mini-computers and arrange for using surplus capacities of three government-owned computers for management reporting.

ELAPSED TIME: 12-18 Months

b. Each branch of service lets contracts for software development.

ELAPSED TIME: 12-18 Months

c. Each branch of service lets contract for data entry.

ELAPSED TIME: 12-18 Months

d. Each branch of service develops software, procedures, and documentation. Test the system with prototype data.

ELAPSED TIME: 18-30 Months

e. Each branch of service develops schedules for user training and production start-up and prepare user manual for classroom training. Instructors also prepare during this period.

ELAPSED TIME: 3 Months

f. Each branch of service trains users with classroom presentations and lab sessions
(each group for two weeks).

ELAPSED TIME: 4 Months

g. Each activity sends, to be keyed; then the data is loaded and verified. (3 months per activity)

ELAPSED TIME: 6 Months

h. Begin "mock" billing until all activities have finished training and loading data. Thie period is overlapping with training and data loading (f and g above).

ELAPSED TIMES: 4 Months

NOTE: Events f. through h. should be phased. If each student could go through a week of lectures and a week of practice, a staff of 6 instructors would be teaching classes for about 4 months. It would be recommended that users having the largest number of accounts be trained first.

7. Implementation Costs. (Using 1978 dollars, in thousands)

a. Management. It was assumed that one project manager and one assistant project manager per branch of service would be necessary to control and coordinate, because, as the local sites are implemented, control would be shifted to the local site level. Three contract specialists would be needed to insure that economical contract services would be procured.

b. Hardware Acquisition. All of the mini-computers would not have to be purchased at once. One would be needed in the beginning for software development. The receipt of the remainder could be phased. When local site personnel complete their training and are ready to begin gathering data, hardware would be needed at that site. Even though the acquisition could be phased through the first year of production, the purchase was assumed to occur in the implementation phase.

c. Software:

(1) Software Development. Development of new software would be more economical than purchasing a commercial package and modifying it (see TABLE 4 on page 14). An interactive package for a mini-computer would be developed.

(2) System Maintenance. After software has been developed, there is a 10 month period where continuing refinement would be undertaken and system requirements would change over time. Twelve programmer/analyst would stay during this period and computer support would need to continue.

d. User Training. Preparation of reference and training materials and user training would be important. The training and documentation functions would be performed in parallel by the three service branches (Navy and Marine Corps, Army, and Air Force). Three months have been allowed for each group of instructors to prepare for the training program. Technical writers would be responsible for the preparation of reference and training materials as well as system documentation. A liberal allotment of resources was planned. One user could represent smallest activities while many might represent the largest activities so an extimated 800 users was used in cost considerations. As control would be at the local level, it would be important that the user have a thorough understanding of the billing system operating procedures. Two groups of students per service branch could be trained during the same time period, one group would be in lecture sessions while the other group would be in lab sessions.

e. Data Load. It was assumed that the keying of the initial data would be performed by contract services. The volume of data per account was assumed to be the same as in FHMUBS. The data control function would be at the local level using the CRT screen display, for the most part.

f. "Mock" billing. After the initial data is loaded, for the period of time that an activity will be waiting for the activities to go through training, "mock" billing will be done. This will allow the activities a chance to "debug" and be readied for "live" billing. "Mock" billing will involve the same procedures as regular production, but the customer will not have to pay for his usage over the norm as will be the case in "live" billing. Throughout this six month period an average of one half of a regular half year of production expenses would be incurred dued to the phased implementation. The largest activities, since they are training first, will "mock" bill from the beginning while the smaller activities would "mock" bill for only that period of time left after their training and initial data load has been done.

TABLE 7

Alternative 1 - Implementation Costs
(Using 1978 dollars, in thousands)

STAFF/OTHER	SKILL LEVEL	LENGTH OF TASKS	COST	REFERENCE
Management:				
3 Project Managers	GS-14	50 Months	675	Fla
3 Project Managers	GS-13	50 Months	571	Fla
3 Contract Specialists	GS-13	15 Months	171	Fla
6 Programmer/Analysts	GS-12	50 Months	960	Fld
		Total	2,377	
Hardware Acquisition:				
Hardware			8,653	F3f(1)
Maintenance		34 Months	1,598	F7a(2)
		Total	$10,251	
Software:				
Development				
6 Programmer/Analysts	Contract	24 Month	998	Fle
12 Programmers	Contract	24 Months	1,696	Fle
3 Technical Writers	Contract	24 Months	349	Fle
Computer Supplies		24 Months	29	F7b(1)
		Total	3,072	
Maintenance				
3 Programmer/Analysts	Contract	10 Months	208	Fle
6 Programmers	Contract	10 Months	354	Fle
Computer Supplies		10 Months	12	F7b(2)
		Total	574	
User Training:				
3 Technical Writers	Contract	3 Months	44	Fle
9 Instructors	Contract	7 Months	306	Fle
800 Users (2 wks each)	GS-05	4 Months	542	Fla
Travel			576	Fld
Typing and Graphics			20	Flg
		Total	1,488	
Data Load:				
Data Entry	Contract	6 Months	487	F7c(3)
Implementation Forms			47	F7c(2)
Computer Support		6 Months	66	F7c(1)
		Total	600	
Mock Billing:				
Forms			49	F7d(2)
Computer Support		4 Months	9	F7d(1)
		Total	58	
Miscellaneous:				
Space and Facilities			1,922	F7e(1)
Mail			120	F7e(2)
		Total	2,042	
IMPLEMENTATION COST			$20,461	

NOTE: Implementation costs are actually within a four year time period. For purpose of analysis all these costs were treated as if they occurred in the middle year of implementation, the zero year of the system life. This treatment should not materially affect system life cost comparisons.

8. Production Costs. (Using 1978 dollars, in thousands)

a. Management. No longer would it be necessary to have assistant project managers and contract specialist after the implementation period has been passed.

b. System Maintenance. System maintenance would be at the same level as the first year.

c. Operations. Cost does not enter into consideration since operations would be performed by meter reading personnel.

d. Data Entry. Cost does not enter into consideration since data entry would be performed by meter reading personnel.

TABLE 8

Alternative 1 - Production Costs
(Using 1978 dollars, in thousands)

STAFF/OTHER	SKILL LEVEL	COST	REFERENCE
Management:			
3 Project Managers	GS-14	162	Fla
6 Programmer/Analysts	GS-12	230	Fla
	Total	392	
Software Maintenance:			
3 Programmer/Analysts	Contract	250	Fle
6 Programmers	Contract	424	Fle
Computer Supplies		14	F3f(2)(g)
	Total	688	
Operations:			
-			
Data Entry:			
-			
Billing:			
Equipment Maintenance		564	F3f(2)(a)
Forms		296	F3f(2)(d)
Central Reporting Costs		28	F3f(2)(f)
	Total	888	
Miscellaneous:			
Space and Facilities		643	F3f(2)(c)
Mail		573	F3f(2)(e)
	Total	1,216	
PRODUCTION COST		$3,184	

9. <u>System Life Cost</u>. (Using 1978 dollars, in thousands)

TABLE 9

Alternative 1 - System Life Cost

YEAR	COST	DISCOUNT FACTOR	NET PRESENT VALUE
0 (Implementation)	20,461	1.00	20,461
1 (Production)	3,184	.95	3,025
2	3,184	.87	2,770
3	3,184	.79	2,515
4	3,184	.72	2,292
5	3,184	.65	2,070
6	3,184	.59	1,879
7	3,184	.54	1,719
8	3,184	.49	1,560
	45,933		38,291

$38,291,000 divided by 310,000 family housing units =

$124 per family housing unit

E. ALTERNATIVE 2 - MULTIPLE MAINFRAME, BATCH - RJE

1. Emphasis. Alternative 2 presents an approach designed to improve upon the mail approach which was determined to be unworkable due to time problems which would be inherent in the mailing approach.

2. Description. Alternative 2 is oriented to time-sharing on 3 government computers using an extended EFHMUBS. There would be three, one for Army, one for Navy and Marine Corps and one for Air Force. One hundred sixty-two of the larger sites would transmit (send) data to the appropriate computer site using remote job entry (RJE) stations.

a. Hardware and Software Support. Each branch of service would provide their own computer site. The multiple computers could be of differing manufacture, level of capacity and communication facilities. Programs and operating procedures would be based upon the prototype system, but each service would expand and modify the system to fit individual preferences.

b. Procedures

(1) Implementation. Personnel at the activities would complete initial data load forms. Data transcription would be performed by contract at the local level and the keyed output transmitted by RJE. The initial data would be reviewed by a quality control staff at the computer center.

(2) Production. Personnel at the activities would complete data forms for updating initial load data, recording weather, performing adjustments, and posting meter readings. Transcribing data would be performed by contractors at the activities and the keyed output transmitted using RJE. A two to 24-hour delay for turnaround would be expected. Billing registers would be transmitted to accounting offices either in a machine-readable format or in hard copy form. The appropriate accounting agencies would furnish receipt data to the utility billing system.

3. Assumptions and Constraints

a. Schedules for the activities would be established, which would insure a reasonable and steady flow of work through the data conversion, computer processing, and quality control areas.

b. Specific accounting interfaces have yet to be determined, but existing systems would be used.

c. Phased implementation would be acceptable. Larger activities would be implemented first; sites with fewer than 500 accounts would be implemented last.

e. System processing time of two weeks would be acceptable. Any one account would be billed monthly, but bills would be processed twice a month.

4. Advantages

a. Good Software Reliability. The software would have been field-tested for a year on the prototype FHMUBS, the system would function with fewer problems.

b. High Data Reliability. Data adjustments would be made more quickly than if mail were used for transmitting data, so the files would be more accurate.

c. Good Response. By using RJE equipment located at the activity, data would be processed on a pre-scheduled basis and results would be returned in less than a day. Questions at the local level concerning status of an account could be more quickly answered relative to the mail approach for all sites. This feature would improve user productivity and morale because the feeling would not exist that accounts were not up-to-date. Management reports would be available sooner than in the case of all site mailing data because the file status would be more current.

5. Disadvantages

a. High cost. Alternative 2 would cost approximately $176 per unit.

b. System Integrity. Maintaining adequate control over a RJE network requires significantly more effort than a system subject to physical control.

c. Limited Flexibility. Alternative 2 would be limited by the workload at the processing sites and the ability of the activities to conform to computer access schecules.

6. Implementation Schedule

a. Each branch would let contracts for software modification and extension, preparation of documentation and training materials.

ELAPSED TIME: 12-18 Months

b. Each branch would make arrangements to use surplus computer capacity by determining hardware requirements, identifying potential processing sites, and establishing computer accounts and funding.

ELAPSED TIME: 12-18 Months

c. Each branch would let contracts for data entry and operations personnel.

ELAPSED TIME: 12-18 Months

d. Each branch would modify and extend software and documentation, and test with the prototype and special case data.

ELAPSED TIME: 12-18 Months

e. Each branch would develop schedules for users and production start-up and prepare user manuals for classroom training. Instructors also would prepare during this period.

ELAPSED TIME: 3 Months

f. Each branch would train users with classroom presentations and lab sessions (each group for two weeks).

ELAPSED TIME: 4 Months

g. Each branch would perform initial data load (3 months for each activity).

ELAPSED TIME: 6 Months

h. Begin "mock" billing until all activities have finished training and loading data. This period is overlapping with training and data loading (f and g).

ELAPSED TIME: 4 Months

NOTE: Events f. through h. should be phased. If each student went through a week of lectures and week of practice, a staff of 3 instructors could be teaching classes for about 4 months. It would be recommended that users having the largest number of accounts be trained first so that the largest volume of data load would occur when data entry staff has no other work.

7. Implementation Cost. (Using 1978 dollars, in thousands)

a. Management. It was assumed that two project managers would be needed for each service to coordinate efforts and each service would have its own contract specialist to acquire commercial services.

b. Software Modification, Extension, and Documentation. The FHMUBS system would provide the starting point. It was assumed that all services would change software and documentation to suit the individual needs of each branch of serive.

c. User Training. The training and documentation functions would be performed in parallel by the three service branches (Army, Navy and Marine Corps, and Air Force). Three months have been allowed for each group of instructors to prepare for the training program. It is expected that training could be completed in all cases within 4 months.

d. Data Entry. The data entry process for implementation was assumed to be performed in the same manner as Alternative 1.

TABLE 10

Alternative 2 - Implementation Costs
(Using 1978 dollars, in thousands)

STAFF/OTHER	SKILL LEVEL	LENGTH OF TASKS	COST	REFERENCE
Management:				
3 Project Managers	GS-14	40 Months	540	Fla
3 Project Managers	GS-13	40 Months	457	Fla
3 Contract Specialists	GS-13	40 Months	457	Fla
6 Programmer/Analysts	GS-12	40 Months	768	Fla
		Total	2,222	
Hardware:				
RJE Purchase		25 Months	9,396	F8a(1)(a)
Maintenance			1,892	F8a(1)(b)
		Total	11,288	
Software:				
Development				
6 Programmer/Analysts	Contract	15 Months	624	Fle
12 Programmers	Contract	15 Months	1,061	Fle
3 Technical Writers	Contract	15 Months	218	Fle
Computer Support		15 Months	167	F8a(2)(a)
		Total	2,070	
System Maintenance				
3 Programmer/Analysts	Contract	10 Months	208	Fle
6 Programmers	Contract	10 Months	354	Fle
Computer Support		10 Months	111	F8a(2)(b)
		Total	673	
User Training:				
9 Instructors	Contract	7 Months	306	Fle
3 Technical Writer	Contract	3 Months	44	Fle
800 Users (2 wks. each)	GS-05	4 Months	542	Fla
Travel			576	Fld
Typing and Graphics			20	Flg
		Total	1,488	
Data Load:				
Data Entry	Contract	6 Months	487	F7c(3)
Forms			47	F7c(2)
Computer Charges		6 Months	77	F8a(3)
		Total	611	
"Mock" Billing:				
Data Entry	Contract	4 Months	239	F8a(4)(a)
Forms			51	F8a(4)(b)
Phone and Communications			212	F8a(4)(d)
Computer Support		4 Months	30	F8a(4)(c)
		Total	532	
Miscellaneous:				
Space and Facilities			753	F8a(5)(a)
Mail Cost			120	F8a(5)(b)
		Total	873	
IMPLEMENTATION COST			$19,757	

NOTE: Implementation costs would be incurred within a five year time period. For purposes of analysis, all these costs were treated as if they occurred in the middle year of implementation which is year zero of the system life. This treatment should not materially effect system life cost.

9. Production Costs. (Using 1978 dollars, in thousands)

a. Management. Management staffing levels would change to reflect the fewer needs in the production years.

b. System Maintenance. All activities are in production for the entire year. System maintenance would be at the same level staffing would decrease from the implementation months for production since there will not be overlapping functions (system development, user training, and data load will be accomplished).

c. Operations. No additional staffing would be needed as the day staff at the three computer facilities would handle the work load.

d. Data Entry, Computer, and Miscellaneous. All activities would have reached full production by this time.

TABLE 13

Alternative 2 - Production Costs
(Using 1978 dollars, in thousands)

STAFF/OTHER	SKILL LEVEL	COST	REFERENCE
Management:			
3 Project Managers	GS-14	162	Fla
6 Programmer/Analysts	GS-12	230	Fla
	Total	392	
System Maintenance:			
3 Programmer/Analysts	Contract	250	Fle
6 Programmers	Contract	424	Fle
Computer Support		133	F8b(1)
	Total	807	
Billing:			
Data Entry	Contract	1,434	F3c(2)(e)
Forms		306	F3a(2)(d)
RJE Maintenance		908	F8b(2)(a)
Phone & Communications		1,270	F8b(2)(b)
Computer Support		177	F8b(2)(c)
	Total	4,095	
Miscellaneous:			
Space and Facilities		330	F8b(3)(a)
Mail Costs		577	F8b(3)(b)
	Total	907	
PRODUCTION COST		$6,201	

9. <u>System Life Cost</u>. (Using 1978 dollars, in thousands)

TABLE 14

Alternative 2 - System Life Cost

YEAR	COST	DISCOUNT FACTOR	NET PRESENT VALUE
0	19,757	1.00	19,757
1	6,201	.95	5,891
2	6,201	.87	5,395
3	6,201	.79	4,898
4	6,201	.72	4,465
5	6,201	.65	4,031
6	6,201	.59	3,658
7	6,201	.54	3,349
8	6,201	.49	3,038
	$69,365		$54,482

$54,482,000 divided by 310,000 housing units =

$176 per housing unit

F. COST AND CALCULATIONS

1. Assumptions

a. All GS salaries are for FY78 top step, with 35% overhead for benefits.

SKILL LEVEL	ANNUAL DOLLARS	+ 35%	TOTAL DOLLARS	MONTHLY DOLLARS
GS-02	9,142	3,200	12,342	1,029
GS-03	10,310	3,609	13,919	1,160
GS-04	11,572	4,050	15,622	1,302
GS-05	12,945	4,531	17,476	1,456
GS-07	16,038	5,613	21,651	1,804
GS-09	19,620	6,762	26,487	2,207
GS-11	23,736	8,308	32,044	2,670
GS-12	28,452	9,958	38,410	3,200
GS-13	33,827	11,839	45,666	3,805
GS-14	39,973	13,991	53,964	4,497

b. All computation is in 1978 dollars.

c. Final dollar figures are expressed in the nearest thousand unless otherwise indicated.

d. 800 Users (an estimated number of meter readers and family housing support people at the activities) travel to one site for training. The cost assumed is $720 per trip (plane ticket $300 and per diem $35 per day for 12 days) per user so the total for 800 users would be $576,000.

e. The following contract rates were used in calculations except where otherwise specified:

Programmer/Analyst	- $40/hr.	- $6932/mo.	- $83,200/yr.
Programmer	- $34/hr.	- $5892/mo.	- $70,720/yr.
Technical Writer	- $28/hr.	- $4852/mo.	- $58,240/yr.
Instructors	- $28/hr.	- $4852/mo.	- $58,240/yr.
Lead Computer Operator	- $22/hr.	- $3813/mo.	- $45,760/yr.
Computer Operator	- $20/hr.	- $3466/mo.	- $41,600/yr.
Tape Librarian	- $20/hr.	- $3466/mo.	- $41,600/yr.
Data Control Clerk	- $17/hr.	- $2946/mo.	- $35,360/yr.
Data Entry Operator	- $14/hr.	- $2426/mo.	- $29,120/yr.

f. A work year has 2,080 hours. A work month has 173.3 hours.

g. Typing and graphics estimate is a guess; expenses would be modest, not to exceed the estimate. The estimated cost is $20,000.

h. Eighty square feet per person is assumed for work area. In the case of two shift workers, the workspace for the day shift is the same as the evening shift. To provide for space requirement, a cost of $.55 per square feet per month was used and $.45 was added to cover the cost of furniture, utilities, and miscellaneous expenses. Workspace is not costed in the case of extra shift workers at a government or a commercial time-sharing facility since the space is provided by the facility.

i. Where used, mini-computers or RJE stations will be placed at sites with more than 500 homes (168 sites plus 6 machines for software development and maintenance) at a cost of approximately $50,000 per machine configuration. Existing RJE equipment could be utilized at a cost savings but the approach was not used in order to give a maximum cost for the case of no equipment being available. The mini-computer approach assumed that the computers be the same model and manufacture so the software could be developed standard to all machines.

j. The base production rate for civil service keypunchers is 9,000 strokes/hr.; the base production rate for contract keypunchers is 10,000 strokes/hr. A 10% higher rate will be used to reflect that some data can be automatically duplicated. For key-to-magnetic media improvement of 15% for civil service and 12.5% for contract are assumed.

2. <u>Hardware Requirements</u>

All requirements were determined by using FHMUBS and expanding to 310,000 accounts.

a. Central Mainframe

(1) About 960 megabytes (MB) of mass storage per month

<u>Account master</u>:
555 MB
(1610 bytes/account X 310,000
accounts divided by .9 usage efficiency)

<u>Period norm</u>:
50 MB
(48 bytes X (620,000 meter readings
+ 310,000 norms) divided by .9 usage efficiency)

<u>Activity</u>:
2 MB
(4190 bytes X 403 activities divided by
.9 usage efficiency)

Program libraries:
6 MB
(750 tracks X 8368 bytes/track)

Audit trail:
124 MB
(1,550,000 transactions (5/account/mo.)
X 80 bytes/record)

Workspace for largest sort:
223 MB
(1.5 X largest input file = 1.5 X
149 megabytes (for a quarter's billing
records))

(2) About 800 hours of wall clock time per month

(a)	Meter readings	=	297.5 hours
(b)	File maintenance	=	375.7 hours
(c)	Bills	=	80.5 hours
(d)	2 back-ups before run	=	16.3 hours
(e)	2 back-ups after run	=	29.1 hours

(3) About 29 hours of CPU time per month
Using bill from Harry Diamond Laboratories for a period of time in 1978 from December 10 through December 23, it was calculated that .085 seconds per meter per billing cycle of CPU time was used. This sample yields a requirement of 33 hours per month. (.085 seconds/meter/cycle x 2 cycles/mo. X 620,000 meters = 105,400 seconds = 29 hrs). *Another sample using the May 11 and May 29* billing cycles in 1979 showed 28 hours of CPU when extended to 310,000 accounts.

(4) About 21.9 million lines of print per month

(a) Bills - 6,200,000 lines
(2 lines/account X 310,000 accounts)

(b) Registers - 2,857,000 lines
(7 lines/account X 310,000 accounts
+ 8 lines/page for heading X (310,000
accounts divided by 4.5 accounts/page)
X 1.05 for scrap)

(c) Meter Reading Document Transaction Register and
Meter Document Edit List - 783,000 lines
(2 lines/account X 310,000 accounts + 8 lines/
page for heading X (310,000 divided by 16
accounts/page) X 1.05 for scrap)

(d) Meter Reading Documents - 9,188,000 lines (310,000 accounts X 25 lines/account X 1.05 for scrap)

(e) Meter Component Listing - 814,000 lines (2 lines/account X 310,000 accounts + 8 lines/page for heading X (310,000 divided by 16 accounts/page) X 1.05 for scrap)

(f) Customer Component Listing - 2,062,000 lines (Using an average estimate of 5 lines/account, 5 lines/account X 310,000 accounts + 8 lines/page for heading X (310,000 divided by 6 accounts/page) X 1.05 for scrap)

Using a rate of 700 lines per minute, printing would take approximately 522 hours per month.

(5) About 30 tapes per month for back-up of the system.

b. Multiple Mainframes. Requirements were figured by using the following information and applying it to central mainframe calculations:

The Navy and Marine Corps have 90,000 accounts or approximately 29% of 310,000 accounts

The Army has 95,000 accounts or approximately 31% of 310,000 accounts

The Air Force has 125,000 accounts or approximately 40% or 310,000 accounts

The results are displayed in TABLE 13.

TABLE 13

Monthly Multiple Mainframe Requirements

	Mass Storage	CPU Time	Wall Clock Time	Lines of Print	Back-Up Tapes
Navy & Marine Corps	278 MB	8 hrs.	206 hrs.	6,351,000	9
Army	298 MB	9 hrs.	274 hrs.	6,789,000	9
Air Force	384 MB	12 hrs.	320 hrs.	8,760,000	12
Totals	960 MB	29 hrs.	800 hrs.	21,900,000	30

c. Mini-computers. It was assumed that an activity where a mini-computer had been placed would have at least 500 accounts, but not more than 10,000. A range figure could be determined for mass storage and lines of print. Since the computers will be purchased, the CPU and wall clock time time will have no real bearing on cost, providing the machine can process this single task satisfactorily.

(1) Approximate range of mass storage per month - 2.7 MB to 28 MB

(a) Mass storage for 500 accounts

Account master:
894,000 bytes
(1610 bytes/account X 500 accounts divided by .9 usage efficiency)

Period norm:
80,000 bytes
(48 bytes X (1,000 meter readings + 500 norms) divided by .9 usage efficiency)

Activity:
5000 bytes
(4190 bytes/activity divided by .9 usage efficiency)

Program libraries:
1,389,000 bytes
(166 tracks X 8368 bytes/track)

Work space for largest sort:
360,000 bytes
(1.5 X largest input file = 1.5 X 240,000 bytes (quarterly reports))

Total space required = 2.7 MB

(b) Mass storage for 10,000 accounts

Account master:
18 MB
(1610 bytes/account X 10,000 accounts divided by .9 usage efficiency)

Period norm:
1.6 MB
(48 bytes X (20,000 meter readings + 10,000 norms) divided by .9 usage efficiency)

Activity:
5000 bytes
(4190 bytes/activity divided by .9 usage efficiency)

Program libraries:
1.4 MB
(166 tracks X 8368 bytes/track)

Work space for largest sort:
7.2 MB
(1.5 X 4,800,000 bytes)

Total space required = 28 MB

(2) Approximate lines of print per month - 16,000 to 326,000 (billing register, bills, abbreviated meter reading documents only)

(a) Lines of print for 500 accounts - 16,275 (500 accounts X (7 lines on register + 20 lines on bills + 4 lines on meter reading documents) X 1.05 for scrap)

(b) Lines of print for 10,000 accounts - 325,500 (10,000 accounts X (31 lines/account) X 1.05 for scrap)

(3) Approximate number of tapes per month - 672 tapes (4 tapes/site X 168 sites)

3. Hardware and Operating Costs

Equipment and maintenance costs were taken from Datapro: The EDP Buyer's Bible and Auerbach Datacomm 80. Annual expenses were based on estimations of costs in 1978 for computer equipment, maintenance, salaries, space, forms, data entry, travel, and data transmission costs during a production year.

a. Purchase Cost - Single Mainframe (using IBM 370/165)

(1) Equipment:	
(a) CPU	2,740
(b) Mass storage unit	144
(c) Magnetic tape input/output	49
(d) Card reader, card punch and printers	133
SINGLE MAINFRAME EQUIPMENT PURCHASE COST	3,066
(2) Annual Expenses:	
(a) Equipment maintenance and COBOL compiler	75

(b)	Personnel			
	3 Project Managers (GS-14)	162		
	9 Programmer/Analysts (6 GS-12 & 3 contract)	480		
	6 Programmers (contract)	424		
	4 Computer Operators (2 shifts, each shift has 1 Lead Computer Operator and 1 Computer Operator)	175		
	1 Tape Librarian	42		
	4 Data Control Clerks (2/shift)	141		1,424
(c)	Space and Facilities			
	Staff of 27, but only 21 workspaces ((21 X 80 sq. ft./person/mo. + 2000 sq. ft./mo.for the computer and operators) X 12 mo. X $1/sq. ft./mo.)			44
(d)	Forms			
	Machine-produced Forms			
	Meter Reading Documents - 3,906,000 forms (2 meters/account/mo. divided by 2/page X 310,000 accounts X 12 mo. X 1.05 scrap divided by 1,500 forms/box X $30/box)		78	
	Utility Bills - 3,906,000 forms (310,000 accounts/mo. X 12 mo. X 1.05 scrap X $.05/form)		195	

Other Forms

Activity Weather Log - 74,000 forms
(1/activity/day X 403 activities X 365 days divided by 2/page)

Fuel Content Change - 5,000 forms
(1/activity/mo. X 403 activities X 12 mo.)

Rate Change - 5,000 forms
(1/activity/mo. X 403 activities X 12 mo.)

Norm Data Changes - 40,000 forms
(Assuming 400/yr./activity X 403 activities divided by 4/page)

Occupant Check-in - 207,000 forms
(Using 2/3 move-in and move-out rate/yr., 310,000 account X 2/3)

Occupant Check-out - 207,000 forms
(Same as Occupant Check-in)

Occupant Data Change - 78,000 forms
(Using 1/account/yr. X 310,000 account divided by 4/page)

New Meter Data - 8,000 forms
(Using 10 accounts/activity/yr. X 403
activities X 2 forms/account)

Meter Data Change - 16,000 forms
(Using an average rate of 20% for meter
reading adjustments/account X 310,000 accounts
divided by 4/page)

Weather Change - 4,000 forms
(1/mo./activity X 12 mo. X 403 activities)

Meter Reading Request Form - 10,000 forms
(Using 2/activity/mo. X 403 activities X 12
mo.)

Audit Trail Request - 29,000 forms
(3/billing cycle X 2 billing cycles/mo.
X 12 mo. X 403 activities)

Report Request Form - 1,000 forms
(Assuming 2/activity/yr. X 403 activities)

Total Other Forms - 684,000

Other Forms Cost (684,000 forms X 1.05 scrap X $.02/form)	14	
Computer Paper (6.5 million lines of print/mo. (cost for meter reading documents & bills has been counted in Other Forms) X 12 mo. X 1.2 scrap divided by 40 lines/page divided by 3,100 pages/box X $25/box)	19	306

(e) Data Entry
Meter Reading Documents - 110 keystrokes
(2 cards)/form
(110 X 3,906,000 = 429,660,000 keystrokes)

Activity Weather Log - 56 keystrokes (2 cards)/form
(56 X 74,000 = 4,144,000 keystrokes)

Fuel Content Change - 30 keystrokes/form
(30 X 5,000 = 150,000 keystrokes)

Rate Change - 28 keystrokes/form
(28 X 5,000 = 140,000 keystrokes)

Norm Data Change - 71 keystrokes/form
(71 X 40,000 = 2,840,000 keystrokes)

Occupants Check-In - 164 keystrokes (3 cards)/form
(164 X 207,000 = 33,948,000 keystrokes)

Occupant Check-Out - 182 keystrokes (3 cards)/form
(182 X 207,000 = 37,674,000 keystrokes)

Occupant Data Change - 296 keystrokes (4 cards)/form
(296 X 78,000 = 23,088,000 keystrokes)

New Meter Data - 106 keystrokes (2 cards)/form
(106 X 8,000 = 848,000 keystrokes)

Meter Data Change - 312 keystrokes (4 cards)/form
(312 X 16,000 = 4,992,000 keystrokes)

Weather Change - 28 keystrokes/form
(28 X 4,000 = 112,000 keystrokes)

Meter Reading Request Form - 77 keystrokes/form
(77 X 10,000 = 770,000 keystrokes)

Audit Trail Request - 35 keystrokes/form
(35 X 29,000 = 1,015,000 keystrokes)

Report Request Form - 20 keystrokes/form
(20 X 1,000 = 20,000 keystrokes)

Utility Bill Receipt - 40 keystrokes/form
(Receipt is included in the bill and only returned if consumption is over the norm. Sixty-two percent of the customers were over the norm in the first six months of the prototype experience. 62% X 310,000 = 192,200 forms/mo. so 40 X 192,000 X 12 = 92,160,000 keystrokes)

Total Keystrokes - 631,561,000

	Data entry cost (51,035 hours (using key to magnetic device keystroke rate of 12,375 keystrokes/hr.) X $14 X 2 (keying and then verifying) + $5,000 for tapes)		1,434
(f)	Mailing Cost (24 mailings (12 to and 12 from computer site) X $5/package/activity X 403 activities)	48	
	($.15 X 310,000 bills/mo. X 12 mo.)	558	606
MAINFRAME PURCHASE ANNUAL COST			$3,889

b. Purchase Cost - Multiple Mainframes (Using 3 IBM 370/138's)

(1) Navy & Marine Corps (approx. 90,000 accounts or 29%)

(a) Equipment:

CPU	348	
Mass storage	114	
Magnetic tape input/output	49	
Card reader, card punch, & printer	77	588

(b) Annual Expense:

Equipment maintenance and COBOL compiler		34
Personnel		
1 Project Managers (GS-14)	54	
3 Programmer/Analysts (2 GS-12 & 1 contract)	160	
2 Programmers (contract)	141	
2 Computer Operators (1 Lead Operator & 1 Operator)	87	
1 Tape Librarian	42	
2 Data Control Clerks	71	555
Space and Facilities Staff of 11, 9 workspaces are needed ((9 X 80 sq. ft./person/mo. + 1,500 sq. ft./ mo. for the computer and operators) X 12 mo. X $1/sq. ft./mo.)		27
Forms (Navy and Marine Corps have approximately 29% of total accounts. The forms cost was developed from pro-rating central mainframe forms cost on this basis: 29% X 306,000 (F3a(2)(d))		89
Data Entry (29% X $1,434,000 (F3a(2)(e)))		416
Mailing Cost (29% X $606,000 (F3a(2)(f)))		176

Navy-Marine Corps Annual Expense = $1,297,000

(2) Army (approximately 95,000 accounts or 31%)

(a) Equipment:
(See Navy and Marines (F3b(1)(a)) +
$39,000 for more disk space) 627

(b) Annual Expense:

Equipment maintenance and COBOL compiler
(An added $1,000/yr. due to
extended mass storage) 35

Personnel Same as Navy and Marine Corps except another shift would be needed to handle the volume of work:	555	
Plus		
2 Computer Operators	87	
2 Data Control Clerks	71	713

Space and Facilities
Staff of 13, 9 workspaces
((9 X 80 sq. ft./person + 1,500 sq. ft/mo.
for the computer and operators)
X 12 mo. X $1/sq. ft./mo.) 27

Forms
(Army has approximately
one third of the total accounts.
Forms costs developed from
pro-rating central mainframe forms cost on
this basis: 31% X $306,000 (F3a(2)(d)) 95

Data Entry
(31% X $1,434,000 (F3a(2)(e))) 445

Mailing Cost
(31% X $606,000 (F3a(2)(f))) 188

Army Annual Expense = $1,502,000

(3) Air Force (approximately 125,000 accounts or 40%)

(a) Equipment:
See Army (F3b(2)(a)) 627

(b) Annual Expense:

Equipment maintenance and COBOL compiler
See Army (F3b(2)(b)) 34

Personnel
See Army (F3b(2)(b)) 713

Space and Facilities
See Army (F3b(2)(b)) 27

Forms
(Air Force has approximately 2/5 of total accounts. Forms costs developed from prorating central mainframe forms cost on this basis: 40% X $306,000 (F3a(2)(d)) 122

Data Entry
(40% X $1,434,000 (F3a(2)(e))) 573

Mailing Cost
(40% X $606,000 (F3a(2)(f))) 242

Air Force Annual Expense = $1,712,000

MULTIPLE MAINFRAME PURCHASE EXPENSE 1,842

MULTIPLE MAINFRAME PURCHASE ANNUAL EXPENSE 4,511

c. Time-Sharing - One Government Site
Purchasing time costs were estimated from charges for the prototype by using charges at Harry Diamond Laboratories. All costs are annual since equipment is not purchased.

(1) Computer Charges

(a) Production

CPU Charges
A cost for production at Harry Diamond Laboratories of $440/mo. for 10,000 accounts was determined from bills for the May 11 and May 28, 1979 billing cycles of FHMUBS.
($440/10,000 accounts X 31 X 12 mo.) 164

	Tape Storage (960 tapes X $1/mo. X 12 mo.)	12	
	Disk Storage (10 disk packs X $10/mo. X 12 mo.)	1	
	Print Charges (21.9 million lines of print/mo. divided by 1,000 lines times $.50/ 1,000 lines X 12 mo.)	131	308
(b)	System Maintenance ($4,700/mo. (F4a(3)) X 12 mo.)		56
(2)	Personnel		
(a)	3 Project Managers (GS-14)	162	
(b)	9 Programmer/Analysts (6 GS-12 & 3 contract)	480	
(c)	6 Programmers	424	
(d)	2 Computer Operators (1 Lead Operator & 1 Operator, evening	87	
(e)	4 Data Control Clerks (2 for day and 2 for evening shift)	141	1,294
(3)	Space and Facilities Staff of 24, 20 workspaces (20 X 80 sq. ft./mo X 12 mo. X $1/sq. ft./mo.)		19
(4)	Forms (See F3a(2)(d) minus computer paper)		287
(5)	Data Entry See F3a(2)(e)		1,434
(6)	Mailing Cost See F3a(2)(f)		606
TIME-SHARING SINGLE GOVERNMENT SITE ANNUAL COST			4,004

d. Time-Sharing - Three Government Sites
(Reference TABLE 13 for requirements, and F3c for costs)

(1) Navy and Marine Corps (approximately 90,000 accounts)

(a) Computer Charges		
Production:		
CPU Time ($440/10,000 accounts X 9 X 12 mo.)	48	
Tape Storage (320 tapes X $1/ mo. X 12 mo.)	4	
Disk Storage (3 disk packs X $10/mo. X 12 mo. (less than $500))	-	
Print Charges (29% X $131,000 (F3c(1)(a)))	38	90
System Maintenance: ($4,700/mo. (F4a(3)) X 12 mo. X 29%)		16
(b) Personnel		
1 Project Manager (GS-14)	54	
3 Programmer/Analysts (2 GS-12 & 1 contract)	160	
2 Programmers	141	
2 Data Control Clerks	71	426
(c) Space and Facilities Staff of 8, 8 workspaces (8 X 80 sq. ft./mo. X 12 mo. X $1/sq. ft./mo.)		8
(d) Forms (29% X $287,000 (F3a(2)(d) minus computer paper))		83
(e) Data Entry See F3b(1)(b)		416
(f) Mailing Cost See F3b(1)(b)		176

Annual Expense for Navy & Marine Corps = $1,215,000

(2) Army (approximately 95,000 accounts or 31%)

(a) Computer Charges

Production:
CPU Time
($440/10,000 accounts X 9.5 X 12 mo.) 50

Tape Storage
(384 tapes/mo. X $1/mo. X 12 mo.) 5

Disk Storage
(4 disk packs X $10/mo. X 12 mo.) -

Print Charges
(31% X $131,000 (F3a(2)(d))) 41 96

System Maintenance:
($4,700/mo. (F4a(3)) X 12 mo. X 31%) 17

(b) Personnel
See Navy and Marines (F3d(1)(b)) 426
plus extra shift to handle volume:
2 Computer Operators 87
2 Data Control Clerks 71 584

(c) Space and Facilities
See Navy and Marines (F3d(1)(c)) 8

(d) Forms
(31% X $287,000 (F3a(2)(d) minus computer paper)) 89

(e) Data Entry
See F3b(2)(b) 445

(f) Mailing Cost
See F3b(2)(b) 188

Annual Expense for Army = $1,427,000

(3) Air Force (appproximately 125,000 accounts or 40%)

(a) Computer Charges

Production:
CPU Time
($440/10,000 accounts X 12.5 X 12 mo.) 66

Tape Storage
(384 tapes/mo. X $1/mo. X 12 mo.) 5

Disk Storage (4 disk packs X $10/mo. X 12 mo. (less than $500))	-	
Print Charges (40% X $131,000 (F3a(2)(d)))	52	123
System Maintenance: ($4,700/mo. (F4a(3)) X 12 mo. X 40%)		23
(b) Personnel See Army (F3d(1)(b))		584
(c) Space and Facilities See Army (F3d(1)(b))		8
(d) Forms (40% X $287,000 (F3a(2)(d) minus computer paper))		115
(e) Data Entry See F3b(3)(b)		464
(f) Mailing Cost See F3b(3)(b)		242

Annual Expense for Air Force = $1,559,000

TIME-SHARING MULTIPLE GOVERNMENT SITES ANNUAL COST 4,201

e. Time-sharing - One Commercial Site
Time-sharing CPU cost at a commercial site was difficult to determine as computer capabilities varied (for example, Rand Corporation operates an IBM 370/158 while Lawrence Berkeley Laboratory operates a CDC 6600 and CDC 7600) and accounting algorithms differed for computing charges. It was decided that an exact comparison could not be made unless the same jobs were run at the government site and then at the commercial. However, from experience with FHMUBS jobs run at Rockwell International, CPU charges were at least three times more than those at Harry Diamond Laboratories.

(1) Computer Charges

(a) CPU Time
($440 X 3 times more X 31 X 12
mo. (See F3c(1)(a))) 491

(b) Tape Storage See F3c(1)(a)	12	
(c) Disk Storage See F3c(1)(a)	1	
(d) Printing Charges See F3c(1)(a)	131	635
(2) Personnel		
(a) 3 Project Managers (GS-14)	162	
(b) 9 Programmer/Analysts (6 GS-12 & 3 contract)	480	
(c) 6 Programmers (contract)	424	
(d) 4 Data Control Clerks (2 for day and 2 for evening)	141	1,207
(3) Space and Facilities Staff of 22, 20 workspaces (20 x 80 sq. ft./mo. x 12 mo. X $1/sq. ft./mo.)		19
(4) Forms (F3a(2)(d) minus computer paper)		287
(5) Data Entry See F3a(2)(e)		1,434
(6) Mailing Cost See F3a(2)(f)		606
TIME-SHARING COMMERCIAL SITE ANNUAL COST		4,188

f. Purchase Mini-Computers

(1) Equipment - DEC PDP 11/23 (Data System 350), per unit figures in <u>dollars</u>:

(a) Basic Machine

Microcomputer with memory management 128K (features power fail auto restart, boot loader, line clock, several I/O ports for 4 lines)	6,800
Disk controller, one disk drive & one data pack	5,100
Additional 5 MB disk drive & data pack	3,800
System cabinet	1,575

Console with 120-180 character/sec. printer	2,600
Cable	55
Operating system software license	6,750
Tape drive, 1600 bpi tape at 45 ips	12,900
Datatriever license	2,160
BASIC license	440
CRT	1,900
Cable	55

(b) Type A - 500 to 1,500 accounts

Basic Machine	44,135
Additional CRT & cable	1,955
	46,090

(c) Type B - over 1,500 to 3,000 accounts

Basic Machine	44,135
Additional 2 CRT's	3,910
Additional disk drive, data pack, & cabinet	5,050
	53,095

(d) Type C - over 3,000 to 4,500 account

Basic Machine	44,135
Additional 3 CRT's	5,865
Additional 2 disk drives, 2 data packs, & cabinets	10,100
	60,100

(d) Type D - over 4,500 accounts

Basic Machine	44,135
Additional 4 CRT's	7,820
Additional 3 disk drives, 3 data packs, & 2 cabinets	13,900
	65,855

TABLE 14

Mini-Computer by Type for Each Service

	Type A	Type B*	Type C	Type D
Navy & Marine Corps	29	11	5	2
Army	26	14	5	1
Air Force	45	35	1	0
	100	60	11	3

* Two mini-compufers have been added under Type B for software development and system maintenance (one each for managment and software staff) for each branch of service.

MINI-COMPUTER EQUIPMENT COST:

(100 X $46,090 + 60 X $53,095 + 11 X $60,109 + 3 X $65,855)) — 8,653

(2) Annual Expense:

(a) Software and Maintenance - $47,000/mo.
($47,000/mo. X 12 mo.) — 564

(b) Personnel

3 Project Managers (GS-14)	162	
6 Programmer/Analysts (GS-12)	230	
3 Programmer/Analysts (Contract)	250	
6 Programmers	424	1,006

(c) Space and Facilities

Staff of 18, 18 workspaces (18 X 80 sq. ft./person /mo. X $1/ sq. ft./mo. X 12 mo.)	17	
Plus (300 sq. ft./mini-computer X $1/ sq. ft./mo. X 12 mo. X 174 machines)	626	643

(d) Forms

Bills (See F3a(2)(d))	195
Meter Reading Documents	78
Other Forms (70% of mainframe cost for Other Forms (see F3a(2)(d)) due to on-line inquiry)	10

Computer Paper (Lower volume of print due to the on-line inquiry. 70% of computer paper F3a(2)(d))	13	296
(e) Mailing Cost Activities without computer would mail forms to computer site in area and billing registers, etc. would be mailed back (235 sites X 24 mailings (12 to and 12 from) X $2/mailing)	11	
Computer sites mail tapes to one mainframe site for rolled-up reports (168 sites X $2/mo. X 12 mo.)	4	
Bills ($.15 X 310,000 bills/mo. X 12 mo.)	558	573
(f) Central Computer Charges CPU Time (Approximately $5/1,000 accounts/ mo. X 310 thousand X 12 mo.)	19	
Tape Storage (720 tapes for total system life X $1/tape X 12 mo.)	9	28
(g) System Maintenance. ($400 (for computer supplies) X 12 mo. X 3 branches of service)		14
MINI-COMPUTER ANNUAL EXPENSE		3,184

4. <u>Software Development Costs</u>

a. EFHMUBS Enhancement Costs - 15 Months

(1) Personnel				
(a) 3 Project Managers	GS-14	15 Months	202	
(b) 3 Programmer/Analysts		15 Months	312	
(c) 6 Programmers		15 Months	530	
(d) 3 Technical Writers		15 Months	218	1,262
(2) Space and Facilities Staff of 15, 15 workspaces (15 X 80 sq. ft./person X 15 mo. X $1/sq.ft./mo.)				18

(3) Computer Support - 15 months

(a) RJE - $1,000/mo.
(estimated from prototype)

(b) Phone Cost - $1,056/mo.
($.20/min X 240 min/day X 22 days)

(c) Connect Time - $792/mo.
($9/hr. X 4 hr./day X 22 days)

(d) Disk Space - $880/mo.
($.02/tracks/day X 2,000 tracks X 22 days)

(e) CPU - $600/mo.
(estimated from prototype)

(f) Supplies, Paper & Misc. - $400/mo.
(estimated from prototype)

Monthly Computer Support - $4,700/mo.
(Total (a) - (f))

Total Enhancement Computer Support Cost ($4,700/mo. X 15 mo.)	71
ENHANCEMENT COST	1,351

b. Commercial Software Modifications - 18 Months

(1) Personnel

(a)	3 Project Managers	GS-14	18 Months	243	
(b)	3 Programmer/Analysts		18 Months	374	
(c)	6 Programmers		18 Months	636	
(d)	3 Technical Writers		18 Months	262	1,515

(2) Space and Facilities
Staff of 15, 15 workspaces
(15 X 80 sq. ft./person X $1/sq. ft./mo. X 18 mo.) — 22

(3) Computer Support
($4,700/mo. (F4a(3)) X 18 mo.) — 85

COMMERCIAL SOFTWARE MODIFICATION COST — 1,619

c. New Development Costs - 24 Months

(1) Personnel

(a)	3 Project Managers	GS-13	24 Months	324	
(b)	3 Programmer/Analysts		24 Months	499	
(c)	6 Programmers		24 Months	848	
(d)	3 Technical Writers		24 Months	349	2,020

(2) Space and Facilities
Staff of 15, 15 workspaces
(15 X 80 sq. ft./person X 24 mo. X $1/sq.ft./mo.) — 29

(3) Computer Support

(a) Purchase of mini-computer to use in development 53

(b) Monthly expenses

Machine maintenance - $300/mo.

Hardware Space and Facilities - $300/mo. (300 sq. ft./mo. for the mini-computer X $1/sq. ft./mo.)

Supplies, Paper and Misc. - $400/mo. (estimated from the prototype)

Mini-Computer Monthly Expense - $1000/mo.

Expense for Computer Support ($1000 X 24 mo.) 24 77

NEW DEVELOPMENT COST 1,778

5. Data Transcription Cost

a. Card Keypunch - Production - In-house

A worker can punch 9,900 strokes/hr. X 40 hr./week X 48 weeks/yr. = 19,008,000 strokes/yr. The load of 631,561,000 strokes/yr. divided by 19,008,000 stokes/yr. = 33 people. Two shifts will be desired for efficient machine usage for keying and verifying.

(1) Personnel

(a)	1 D. E. Manager		GS-09	12 Months	26	
(b)	2 D. E. Supervisors		GS-07	12 Months	43	
(c)	33 Verifiers		GS-05	12 Months	577	
(d)	33 Keypunchers	8	GS-04	12 Months	125	
		17	GS-03	12 Months	237	
		8	GS-02	12 Months	99	1,107

(2) Machine Rate - $156/mo./machine ($156/mo./machine X 12 mo. X 33 machines) 62

(3) Space and Facilities (69 X 80 sq. ft. X 12 mo. X $1/sq.ft./mo.) 66

(4) Card Cost - $1.50/1,000 card (9,880,000 X $1.50) 15

Key to Card Staffing In-House Cost 1,250

b. Magnetic Device Keypunch - Production - In-house
A worker can punch 11,385 strokes/hr. X 40 hrs./week X 48 weeks/yr. = 21,859,000 stokes/yr./person. The load of 631,561,000 strokes/yr. divided by 21,859,000 strokes/yr. = 29 people.

(1) Personnel

(a)	1 D. E. Manager		GS-09	12 Months	26	
(b)	2 D. E. Supervisors		GS-07	12 Months	43	
(c)	29 Verifiers		GS-05	12 Months	507	
(d)	29 Keypunchers	7	GS-04	12 Months	109	
		15	GS-03	12 Months	209	
		7	GS-02	12 Months	86	980

(2) Machine Rate - $156/mo./machine
($156/mo./machine X 12 mo. X 29 machines) 54

(3) Space and Facilities
(61 X 80 sq. ft. X 12 mo. X $1/sq.ft./mo.) 59

(4) Tape Cost - $12.50/tape
(30 tapes/mo. X $12.50 X 12 mo.) 5

Key to Tape Staffing In-House Cost 1,098

c. Key to Card - Production - Contract
Keystrokes - 11,000/hr.
Cost - $14/hr. + materials
(631,561,000 keystrokes divided by 11,000 keystrokes/hr. X $14 X 2 (key and verify) + $17,000 for cards (F5a(4))) 1,625

d. Key to Tape - Production - Contract
Keystrokes - 12,375/hr.
Cost - $14/hr. + materials
(613,561,000 keystrokes divided by 12,375 keystrokes/hr. X $14 X 2 (key and verify) + $5,000 for tapes (F5b(4))) 1,393

6. Norm Costs

a. Savings which would result if the norm were eliminated:

(1) Implementation

(a) $47,000 forms cost X 50% of forms cost for 1,116,000 forms for building survey and changes to it for norm calculations (see F7a(2)(a) and F7a(2)(f), respectively) 24

(b)	$487,000 data entry cost X 35% of total data entry cost involving keying and verifying 75,144,000 keystrokes for building survey and changes to it for norm calculations (see F7a(3)(a) and F7a(3)(d))	170	
(c)	$24,000 mail charges X 50% of mail charges for mailing 50% of the forms (see F7e(2)(a)))	12	206

(2) Production

(a)	$14,000 other forms cost X 17% of forms cost for 118,000 forms for activity weather logs, norm data changes, and weather changes for norm calculations (see F3a(2)(d))	2	
(b)	$1,434,000 data entry cost X 1% of data entry costs for keying and verifying 7,096,000 keystrokes for activity weather logs, norm changes, and weather changes (see F3a(2)(e))	14	
(c)	$48,000 mailing cost X 17% of mail charges for mailing 17% of the forms (see F3a(2)(f))	8	24

b. Saving or expense which would result if norm data were varied ± 50%:

(1) Implementation (Total saving or expense (see F6a(1)) X ± 50%) ± 91

(2) Production (Total savings or expense (see F6a(2)) X ± 50%) ± 12

7. Alternative 1 Implementation Calculations

a. Hardware Acquisition

(1) Purchase
See F3f(1) 8,653

(2) Maintenance:
Since the machine configuration varies depending on the number of CRT's and disk packs, a category by category maintenance costs was totalled yielding $47,000/mo. for 174 mini-computers: 168 for activities and 2 for each service for system development and user training. Maintenance has been assumed throughout implementation after the contract has been let.
($47,000/mo./174 mini-computers X 34 mo.) 1,598

b. Software:

(1) Development
($400/mo. for computer supplies X 24 mo. X 3 branches of service) 29

(2) System Maintenance
($400/mo. for computer supplies X 10 mo. X 3 branches of service) 12

c. Data Load

(1) Computer Support

(a) CPU Time
Samples from the prototype show a cost of $2.50/thousand transactions for data load. Using the estimated 5 transactions/account to implement that account gives 310,000 X 5 = 1,550,000 transactions.
(1,550 thousand X $2.50/thousand) 4

(b) Magnetic Tapes
It is assumed that all tapes arepurchased at the outset for the needs of the entire system life. Mini-computers at 168 sties need approximacely 4 tapes/mo. for local retention for 6 months and approximately 30 tapes per generation for history and back-up for an estimated 26 generations for the entire systemlife.
(4 tapes/mo. X 168 sites X 6 mo. + 26 generations X 30 tapes/generation = 4,812 tapes.
4,812 tapes X $12.50/tapes). 60

(c) Print Charges
(Using 1 line of print/card X 3,720,000 cards + 280,000 lines for headings, 4 million lines of print would be needed for processing building survey information.
(4 million lines divided by 1,000 lines X $.50/1,000 lines)) 2 66

(2) Forms

(a) Building survey - 930,000 forms
(3 forms/account X 310,000 account)

(b) Occupant Check-in - 310,000 forms
(1 form/account X 310,000 accounts)

(c) New Meter - 620,000 forms
(1 form/meter X 2 meters/account X 310,000 accounts)

(d) Fuel Content - Less than 1000 forms
(1 form/actitity X 403 activities)

(e) Rate - 1,000 forms
(1/utility X 2 utilities, using gas and electricity, X 403 activities)

(f) Changes - 372,000 forms
(Total (a) - (e), 1,861,000 X 20% error rate assumed due to new operations)

Total forms = 2,233,000 forms

Total forms cost
(2,233,000 X 1.05 scrap X $.02) 47

(3) Data Entry

(a) Building Survey - 202 keystrokes (3 cards)/ account. (202 keystrokes X 310,000 accounts = 62,620,000 keystrokes)

(b) Occupant Check-In - 164 keystrokes (3 cards)/form (164 keystrokes X 310,000 forms = 50,840,000 keystrokes)

(c) New Meter - 106 keystrokes (2 cards)/form (106 X 620,000 forms = 65,720,000 keystrokes)

(d) Changes (Assuming 20% more keystrokes needed due to changes = 179,180,000 X .20 = 35,836,000 keystrokes)

Total keystrokes for implementation = 215,016,000

Total Cost (215,016,000 divided by 12,375 keystrokes/ hr. X $14/hr. X 2 (key and verify)) 487

d. "Mock" Billing
Since "mock" billing will average for cost purposes to be one half of a 4 month "production" period, cost can be 1/6 of production year costs in many instances.

(1) Central Reporting Computer Support

(a) CPU Time (Approximately $5/1,000 X 310 thousand/mo. X 4 mo.) 6

(b) Tape Storage (780 tapes for system life X 4 mo. X $1/mo./tape) 3 9

(2) Forms (1/6 X $296,000 (F3f(2)(d)) 49

e. Miscellaneous:

(1) Space and Facilities

(a) Computer (300 sq. ft./mini-computer X 174 mini-computers X $1/sq. ft./mo. X 34 mo.) 1,775

(b) Personnel			
Project Managers	300 man-months		
Contract Specialist	45 man-months		
Programmer/Analysts	474 man-months		
Programmers	348 man-months		
Technical Writers	81 man-months		
Instructors	63 man-months		
	1,311 man-months		
(1,311 man-mo. X 80 sq. ft./man-mo. X $1/sq. ft./man-mo.)		105	
(c) Classrooms (2,000 sq. ft. for mini-computer plus lab space + 1,500 sq. ft. for lecture space) X $1/sq.ft./mo. X 4 mo. X 3 branches of service)		42	1,922

(2) Mail Cost

(a) Data Load ($5/package/activity X 403 activities X 12 mailings (6 to and 6 from))	24	
(b) "Mock" Billing (1/6 X $573,000 (F3f(2)(e)))	96	120

8. Alternative 2 Calculations

a. Implementation

(1) Hardware

(a) Purchase - IBM 3770/3777 (in dollars)		
Keyboard and Terminal with 870/1,200 lpm printer	$41,400	
Card Reader 400 cpm	7,800	
Communication Interfaces	4,800	
	$54,000	
($54,000/RJE station X 174 stations)		9,396
(b) Equipment Maintenance ($435/mo./RJE station X 25 mo. X 174 RJE stations)		1,892

(2) Software

(a) Development

<u>Phone Cost</u> - $1,056/mo.
($.20/min X 240 min/day X 22 days)

<u>Connect Time</u> - $792/mo.
($9/hr. X 4 hr./day X 22 days)

<u>Disk Space</u> - $880/mo.
($.02/track/day X 2,000 tracks X 22 days)

<u>CPU</u> - $600/mo.
(estimated from prototype)

<u>Supplies, Paper</u> & <u>Misc.</u> - $400/mo.
(estimated from prototype)

Total - $3,700/mo.
($3,700/mo. X 15 mo. X 3 branches of service) 167

(b) System Maintenance
($3,700/mo. (F8a(2)(a)) X 10 mo. X 3 branches of service) 111

(3) Data Load - Computer Support

(a) CPU Time
Samples from the prototype show a cost of $2.50/thousand transactions for data load. Using the estimated 5 transactions per account to load the initial data gives 310,000 accounts X 5 transactions.
(1,550 thousand X $2.50) 4

(b) Disk Purchase
Ten 3340 disk packs are required to process system and maintain the files.
(10 disk packs X $4,800/disk pack) 48

(c) Disk Storage
(10 disk packs X $10/mo. X 6 mo.) 1

(d) Tape Purchase
For estimation purposes, all back-up tapes are acquired during implementation.
(30 tapes/mo. X 6 mo. + 26 generations/system life X 30 tapes/generation X $12.50/tape) 12

(e) Tape Storage (960 tapes X $1/mo. X 6 mo.)	6	
(f) Computer Paper (4 million lines divided by 40 lines/page divided by 3,100 pages/box X 1.2 for scrap X $25/box X 6 mo.)	6	70
(4) "Mock" Billing		
(a) Data Entry (1/6 X $1,434,000 (F3a(2)(e)))		239
(b) Forms (1/6 X $306,000 (F3a(2)(d)))		51
(c) Computer Support (1/6 X $177,000 (F8b(2)(c)))		30
(d) Phone & Communications (1/6 X $1,270,000 (F8b(2)(b)))		212
(5) Miscellaneous		
(a) Space and Facilities		

<u>Personnel</u>

Project Managers	240 man-months
Contract Specialists	120 man-months
Programmer/Analysts	360 man-months
Programmers	240 man-months
Technical Writers	54 man-months
Instructors	63 man-months
	1,077 man-months

(1,077 man-months X 80 sq. ft./man-mo. X $1/sq. ft./man-mo.)	86	
<u>RJE Equipment</u> (150 sq. ft./RJE station/mo. X 174 RJE stations X 25 mo.)	625	
<u>Classrooms</u> ((1,500 sq. ft. for lecture + 2,000 sq. ft. for RJE and lab session works-space) X 4 mo. X $1/sq. ft./mo. X 3 branches of service)	42	753

(b) Mailing

<u>Data Load</u>
($5/package/activity X 403 actitivites X 12 mailings (6 to and 6 from)) 24

<u>"Mock" Billing</u>
(1/6 X $577,000 (F8b(3)(b))) 96 120

b. Production

(1) System Maintenance
($3,700/mo. (F8a(2)(a)) X 12 mo. X 3 branches of service) 133

(2) Billing

(a) RJE Maintenance
($435/mo./RJE station X 12 mo. X 174 RJE stations) 908

(b) Phone & Communications
($21/hr. (toll and connect time)/activity X 30 hr./mo. X 12 mo. X 168 activities) 1,270

(c) Computer Support
(F3c(2)(a) minus Print Charges) 177

(3) Miscellaneous

(a) Space and Facilities
<u>Personnel</u>

Project Leaders	36	man-months
Programmer/Analysts	108	man-months
Programmers	72	man-months
	216	man-months

(216 man-mo. X 80 sq. ft./man-mo. X $1/sq. ft./man-mo.) 17

<u>RJE Equipment</u>
(150 sq. ft./RJE station X 174 RJE stations X $1/sq. ft./mo. X 12 mo.) 313 330

(b) Mail
<u>Smaller sites</u>
(235 activities X 24 mailings for forms for keying (12 to and 12 from) X $2/package + 235 actitivies X 12 mailings of hardcopy print-out X $3/package) 19

<u>Bills</u>
($.15/bill/mo. X 310,000 bills/mo. X 12 mo.) 558 577

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NAVAL AUDIT SERVICE

AUDIT REPORT

SERVICE TO MANAGEMENT WORLD-WIDE

AUDIT REPORT A61134

PACIFIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PEARL HARBOR, HAWAII

7 JULY 1975

NAVAL AUDIT SERVICE WESTERN REGION

FOR OFFICIAL USE ONLY

3. Electricity consumption at Navy family housing

a. PACNAVFACENGCOM is responsible for administering the operation and maintenance program for about 27,000 family housing units located at 24 Pacific activities but does not effectively monitor the electricity consumption at these activities to achieve the goals of the energy conservation program. If the 15 per cent goal of reducing electricity consumption established by this program could be achieved, costs of over $1.2 million annually could be avoided.

b. OPNAV Instruction 4100.5 of 13 June 1974 establishes the Navy's shore facilities energy conservation goal of 15 per cent overall reduction compared with the corresponding period of FY 1973. Our review showed that only four of the 24 activities under PACNAVFACENGCOM cognizance had achieved this, and that nine activities had actually increased electricity consumption per housing unit during the first nine months of FY 1974. FY 1973 family housing electricity costs were over $7.3 million and corresponding FY 1974 costs are estimated to be about $9.4 million.

c. PWCs Pearl Harbor, Guam, and Subic Bay administer and maintain about 10,000 family housing units, representing in total 38 per cent of the total housing units under PACNAVFACENGCOM cognizance. Exhibit A shows the actual FY 1973 and 1974 electricity consumption per family housing unit, and the projected consumption for FY 1975 based on budget submissions of the three PWCs. It also shows the 15 per cent reduction goal for each PWC. Our review of FY 1974 electricity consumption by family housing units located at the three PWCs showed that if consumption were reduced 15 per cent in accordance with the cited OPNAV directive, annual costs of about $1.2 million could be avoided (Appropriation 17-97_0700). Details are:

	Subic Bay	PWC Guam	Pearl Harbor
(1) Average number of occupied housing units	1,388	2,490	6,077
(2) Actual FY 1973 average consumption per occupied housing unit (KWH)	46,636	40,087	14,300
(3) FY 1974 consumption goal per occupied housing unit (KWH) (85% of FY 1973 consumption)	39,641	34,074	12,155
(4) Actual FY 1974 average consumption per occupied housing unit (KWH)	39,939	37,483	17,037
(5) FY 1974 consumption exceeding 15% reduction goal (KWH) (4) - (3)	298	3,409	4,882
(6) FY 1974 composite billing rate per KWH	$.01950	$.02525	$.03278
(7) Savings per occupied housing unit if consumption reduced by 15% (5) x (6)	$5.81	$86.08	$160.03
(8) Total savings if consumption reduced by 15% (1) x (7)	$8,064	$214,339	$972,502

As shown, electricity consumption at PWC Pearl Harbor increased by 19 per cent ((17,037 - 14,300) ÷ 14,300) per family housing unit during FY 1974. This increase, together with an increase in the electricity billing rate during the FY 1974 fourth quarter, necessitated the transfer of $500,000 from maintenance (BP 20) funding to operation (BP 10) funding. FY 1975 projected electricity consumption of the three PWCs showed that PWCs Guam and Subic Bay are making efforts to reduce consumption by 15 per cent per family housing unit, while PWC Pearl Harbor is anticipating yet another increase of 19 per cent as shown in Exhibit A. Using the FY 1975 billing rate of $.03943 per KWH, this increase in consumption will cost about $700,000.

d. A July 1973 Booz-Allen study identifies Navy family housing as using 20 per cent more energy than comparable civilian housing. However, our review showed that Navy family housing in Hawaii in fact uses 50 per cent more electricity than comparable civilian housing. This is based on average consumption of 1,420 KWH per month by Navy

Over or under billing?

family housing units during FY 1974, as compared to an average of 950 KWH per month by comparable civilian housing based on a recent study made by Hawaiian Electric Company. The Booz-Allen study states that lack of accountability through the absence of individual metering is the probable reason for this difference.

e. We believe that this factor as well as the construction of new family housing with central air conditioning (A/C) accounts for the increase in consumption by Navy family housing. This is based on data obtained by individual metering for 46 family housing units at five Navy housing sites with central A/C units. Electricity consumption for the 7-month period ended 31 July 1974 showed that A/C accounted for 28 to 40 per cent of total electricity consumption, as follows:

Location	Ranking by use	Type of housing	No. of units metered	Average monthly KWH consumption per unit: Total usage	A/C	% of total
Barbers Point	2	Company grade 3-bedroom	8	2,201	792	36.0%
Barbers Point	5	Enlisted grade 2-4 bedroom	12	1,783	726	40.7
Camp Stover	4	Enlisted grade 2-4 bedroom	8	1,964	558	28.4
Catlin Park	3	Enlisted (CPO) 2-bedroom	12	2,051	816	39.8
Maloelap	1	Senior grade 4-bedroom	6	2,730	988	36.2

4 mo ile: 1400 64% 909 KWH/mo

Based on occupancy data, we also noted wide variance between low and high users of electricity for A/C during the same period, as follows:

Location	Monthly KWH consumption for central A/C per family housing unit: High	Low	Average
Barbers Point	1,213	374	809
Barbers Point	1,164	52	730
Camp Stover	979	91	565
Catlin Park	1,356	438	824
Maloelap	1,593	192	985

PWC meter readers found that high users are not observing conservation measures by keeping window jalousies and sliding doors closed, and that low users are turning off A/C units when not needed for comfort.

f. In essence, achieving the Navy goal of reducing energy consumption by 15 per cent can only be accomplished through active occupant participation. Under present guidelines, this reduction in electricity consumption will have to come from voluntary actions on the part of the occupant. Consequently, there is no direct personal involvement to reduce consumption since utilities are furnished without charge with forfeiture of Basic Allowance for Quarters (BAQ) when public quarters are occupied by military personnel. With emphasis on an all-voluntary Navy and with greater amenities offered, there is a definite need to consider developing legislative changes for constructively reducing energy consumption without dramatically altering life styles and standard of living. An alternative may be the establishment of rents and charges for adequate public quarters similar to procedures established for inadequate public quarters, as set forth in Housing Administration (NAVFAC P-352), par. 8.3.4. This directive states that "The cost versus income policy, if carefully explained, should be an incentive to the occupant to do their part to keep costs down by performing occupant maintenance and conserving utilities."

Recommendation 3. PACNAVFACENGCOM effectively monitor electricity consumption by Navy family housing to achieve 15 per cent reduction in consumption, as required by OPNAV Instruction 4100.5.

Recommendation 4. NAVFAC initiate a study to determine whether legislative changes need to be developed in regard to charging occupants of Navy family housing for electricity used to constructively reduce electricity consumption at Navy activities with family housing mangement responsibilities.

PACNAVFACENGCOM management response (Recommendation 3). Concur in the recommendation. Electricity consumption at Navy activities and family housing will continue to be reviewed during Utility UIP/Energy Conservation visits.

NAVAUDSVCWEST comment (Recommendation 3). PACNAVFACENGCOM's planned action should correct the noted condition.

4. Metering family housing electricity usage

a. PACNAVFACENGCOM does not provide master metering for each family housing project to permit accurate determination and effective

ALTERNATIVE STRATEGIES FOR OPTIMIZING ENERGY SUPPLY, DISTRIBUTION, AND CONSUMPTION SYSTEMS ON NAVAL BASES

VOLUME I: NEAR-TERM STRATEGIES

T. Consroe, S. Hatcher, J. Nicholas, and J. Nichols

J. Mateyka: Project Engineer

R. Shaw: Research Director

for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
AND NAVAL CIVIL ENGINEERING LABORATORY

Contract Number N62399-73-R-0029

November 16, 1973
Report Number BA 9005-364

BOOZ·ALLEN & HAMILTON

ENERGY RESOURCES GROUP

X. METERING OF ELECTRICITY FOR FAMILY HOUSING

X. METERING OF ELECTRICITY FOR FAMILY HOUSING

The subject of this chapter is an assessment of the effect which electric metering of individual Navy residences could have on reducing consumption levels and conserving energy. This strategy is not fully consistent with the selection criterion requiring that personnel actions not be called upon to make the strategy work. However, because it was observed at the two test bases that energy consumption considerably exceeded the consumption in equivalent houses in the neighboring communities, it was decided to investigate this strategy.

1. SUMMARY OF RESULTS

The analysis given in this chapter demonstrates that, notwithstanding institutional constraints, a change to individual metering and billing of utilities for naval family housing will cause a general decrease in the level of electricity consumption which is more than enough to offset the cost of such a change. The results of the cost/benefit analysis are summarized in Table X-1. The following additional results and conclusions are also pertinent.

supporting data?

not true in AF

- Electricity consumption levels for naval housing appear to be substantially higher than those for comparable civilian housing. Because electrical usage is a complex function of many physical and human variables, an explicit and detailed comparison of military and civilian housing units and consumption patterns was outside the scope of this analysis.

therefore excessive consumption

A F projects no savings

- Individual metering will certainly produce some amount of electrical savings. A reduction of only 6 percent of the projected average Navy household consumption would be enough to offset the costs of installing the meters.

installation only

- The decrease in electrical usage due to implementation of this technique cannot be determined precisely; however, reductions of 10 and 20 percent were postulated as being well within the possible savings range. This assumption

by whom

Table X-1
Metering of Family Housing: Summary of Results

	Pensacola	Navy
• Energy Savings/Yr. 10^6 kWh	1.92	170
• Program Cost, Millions of 1973 Dollars	.067	9.435
• Net Benefits, Millions of 1973 Dollars	.134	14.365
• Benefit/Cost Ratio	4/1	2.5/1
• Breakeven Point, Years	0.7	1.2

Note: Based on postulated 20-percent reduction in electricity consumption.

not a valid assumption

is based on the results of empirical analyses of savings attributed to the installation of meters.

- Projections for the future price of electricity used in the analysis are relatively conservative; more abrupt price escalations would mean proportionately greater savings.

- The importance of conservation of electricity will increase as the use of electric air conditioning increases in Navy housing.

Note On the pessimistic side, a change to individual family unit metering and billing could not be accomplished without some institutional changes within the Navy. Admittedly, this may be a large obstacle to implementation of this strategy. In addition, there may be legal problems involved. If a base purchases substantial amounts of electricity, there are major legal and regulatory questions as to whether this purchased electricity can be resold.

This analysis is presented in spite of these negative considerations in order to quantify this energy conservation technique in terms of potential energy savings and economic benefits. Though there are alternatives to direct billing, once meters are installed, incentives or competitions could be initiated to reduce consumption. It is doubtful that such practices would produce savings as large as those obtained from direct billing, but given possible institutional constraints, they should be considered.

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FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
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2. TECHNOLOGY ASSESSMENT

A substantial part of Navy real property and prime energy consumption is devoted to family housing units for naval personnel. In most of these housing units, utilities are not currently metered because personnel are not required to pay for utility services directly. There is compelling evidence that the utility consumption levels for these unmetered units in general are somewhat higher than those for similar units in the civilian sector. There is also evidence that if meters were installed and Navy families were billed for utilities, that consumption levels could be reduced more than enough to offset the costs associated with such a change.

really.

AF findings do not confirm this "evidence".

This analysis focuses only on electrical consumption and metering because:

- There is useful civilian sector data related to electric metering. really?

- A high percentage of family housing energy consumption is electricity, and not gas or oil.

- General results for electric metering would tend to be indicative results which might be obtained from the metering of other utilities.

No - as heating is a function of variable weather.

3. ENERGY CONSERVATION

(1) Electric Consumption Patterns at Great Lakes and Pensacola

Detailed housing and utility data[1, 2] were collected at Great Lakes and Pensacola, and these data are presented in Tables X-2 and X-3. At Pensacola, each of the six housing "developments" is metered for electricity, and monthly readings are available. In addition, the 25 units described as "Bldg 1789-1801" are metered individually. Unfortunately, the housing at Great Lakes is not metered as precisely. In most instances, the only metering available is at the substation level and sometimes at the major feeders from the substations. There are no meters with reliable or complete readings on lines serving housing exclusively at Great Lakes. Only three feeder lines

Table X-2
Consumption Patterns for Three Electric Power Feeders at Great Lakes

	Feeder		
	G-50	G-53	G-63
Total Floor Area Served, 10^3 sq. ft.	539	1346	453
Housing Floor Area, 10^3 sq. ft.	324	1268	148
Units	210	943	102
Total Elec., MWh	4247	9832	1672
Percent Area, Housing	61	94	49
Percent Elec., Housing	61 (1)	94 (2)	64 (3)
Elec., Housing, MWh	2600	9250	1062
kWh/Unit	12100	9800	10400
kWh/sq. ft.	7.9	7.3	7.2 (4)
sq. ft./Unit	1540	1360	1450

How about KWH/body

. Average kWh per unit: 10,000
. Average sq. ft. per unit: 1,400

Notes:

(1) Non-housing area is mostly administration and community facilities, so assume same kWh/sq. ft. as for housing, since usage patterns would be similar. No!

(2) Non-housing area is mostly community facilities, so again assume same kWh/sq. ft. as housing. No!

(3) Most non-housing area is storage, which should show a substantially lower usage pattern, so assume only 2 kWh/sq. ft. for non-housing. ?

(4) Due to (3), this is only an estimate, included not as contributing data but only as non-contradicting data. ?

Table X-3
Electricity Consumption Patterns in Pensacola Housing Developments

Development Name	Housing Units	Total Elec. MWh	10^3 Sq. Ft. Floor Area	kWh/ Unit	kWh/ Sq. Ft.	Sq. Ft. Unit	Type A/C
Woolsey	80	544	42	6,800	13.0	524	Window
Moreno Cts.	198	1,611	141	8,100	11.5	702	(Not ident[illegible]d)
Crescent (250)	250	6,050	382	24,000	15.8	1,520	Central
Bldg. 1789-1801	25	281	31	11,225	9.2	1,232	Central
Hospital Compound	11	228	22	20,800	10.4	2,000	Window
Crescent 1, 2	36	884	91	24,400	9.6	2,540	Central
Total	600	9,598	709				

. Avg. kWh per unit: 16,000 What other appliances and

. Avg. sq. ft. per unit: 1,180. What is the saturation?

Note: The development name used above may not be the colloquial name; it is the one which appears on the electricity meter sheet.

serving areas devoted primarily to housing had reliable meter readings. Thus, the data from Great Lakes should not be considered to be as definitive as that from Pensacola. For Great Lakes, the exact amount of electricity used for nonhousing applications had to be estimated and deducted from the feeder total.

Natural gas is used for hot water, space heating, and cooking for housing at both Great Lakes and Pensacola. There is no steam or electric heat. Any air-conditioning, including all central units, is electric. a Seasonal Variation

Tables X-2 and X-3 show that for housing units at Great Lakes, the average floor space is between 1360 and 1540 square feet, and the average annual electricity consumption is between 9800 and 12,000 kWh per unit. At Pensacola, where better data were available, housing units are between 524 and 2540 square

feet, and have consumption of between 6800 and 25,400 kilowatt hours per unit per year. From these data, some further conclusions can be drawn concerning consumption patterns.

- Consumption at Pensacola is generally higher than at Great Lakes, due largely to the higher summer air conditioning load. Most homes at Pensacola are at least partially air-conditioned by electricity, whereas most of the homes at Great Lakes are not. Many homes are entirely air-conditioned by a central unit; those that are not often have one or more window units.

to general for a valid study

- The spread in average consumption per unit can be attributed in part to the variation in average floor space per unit. It is expected that larger homes will account for proportionately more electricity usage, especially if they are centrally air-conditioned.

?

It is difficult to compare military and civilian usage of electricity because of various factors such as life style, affluence, vacancy periods, etc., which contribute to some extent to the usage pattern. In addition, the comparison of construction characteristics of military and civilian housing requires careful analysis. The statistics shown in Table X-4 are presented, therefore, as a general comparison only. In all cases,

Table X-4
Average Annual Residential Use of Electricity Per Household

Type and Location of Residence	Average Annual Consumption, kWh	Notes
Nationwide (1971)[5]	7,380	b, d
"Characteristic Suourban Home" (1972)[3]		a, c
• Without electric central air conditioning	8,120	
• With electric central air conditioning	10,700	
Pensacola, Fla. - Civilian (1971)[4]	10,600	b, d
Waukegan, Ill. - Civilian (1971)[4]	7,889	b, d

Notes:
a - Floor area 1700 square feet per unit
b - Floor area unavailable
c - Space heating, hot water, and stove: natural gas
d - Space heating, hot water, and stove information unavailable.

annual electric use has been taken from average residential electric bills. Not valid.

Figure X-1 illustrates the difference between Navy and civilian electrical consumption in the Great Lakes and Pensacola areas. Some comments about such a comparison are appropriate:

- A definitive comparison clearly cannot be made without correlating such factors

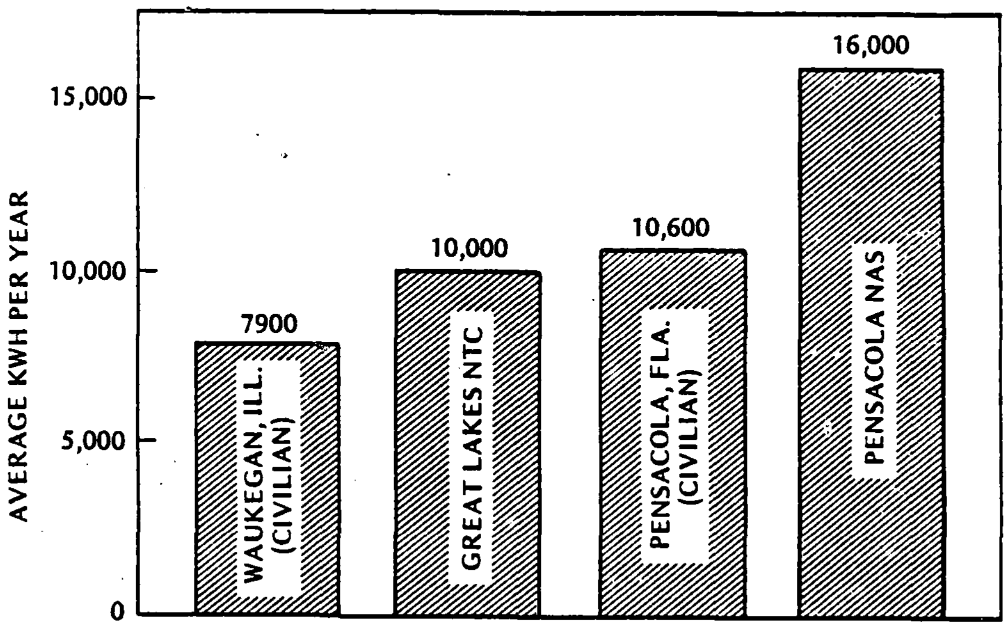
  - Floor area per unit
  - Heating, hot water, major appliance, and air-conditioning information + appliance saturation
  - Housing construction parameters
  - Relative family affluence
  - Family size.

  Hence, the results in Figure X-1 are to be taken as illustrative.

- Figure X-1 is not intended to support the contention that Navy housing at Great Lakes or Pensacola is responsible for "over-consumption" of precisely 2100 and 5400 kWh, respectively. The purpose of the bargraphs is to illustrate qualitatively that Navy consumption levels in general are higher than comparable civilian levels.

(2) Metering

When utility costs for a large group of housing units are paid by a single party (usually the owner or landlord), the system is sometimes referred to as "master-metering". This is in contrast to the more common practice of direct billing of individual customers. A major characteristic of Navy housing is that, with only a few exceptions, utilities are master-metered. In addition, the data clearly demonstrate that per household electrical use is somewhat higher than should be expected when



NOTE: FOR SOURCE AND EXPLANATION, SEE TEXT.

FIGURE X-1
Average Electrical Consumption Per Family Per Year (1971) in Comparable Housing Units

compared to the civilian sector. Thus, there is a potential for energy conservation by switching from widespread master-metering to individual metering.

There are very few statistical data available indicating exactly how much electrical usage can be reduced by switching to an individually metered system. A definitive experiment would involve residences and families very carefully matched with regard to size, income, life style, etc. Such a controlled experiment apparently has never been performed. Reference (6) contains perhaps the best data of this type. It describes how a section of low-rent housing was switched from a master-metered to an individually metered system; the initial drop in consumption was about 20 percent. This result can also be supported by basic economic reasoning. When you do not pay the electric bill yourself, there is a tendency to:

was the 20% sustained or a short time situation

- Leave lights on in rooms used only occasionally

- Leave a number of lights on when no one is home in the evening
- Leave doors/windows open when heating/cooling units are operating
- Set air-conditioning thermostats very low
- Use washing machines and clothes dryers with less than a full load.

There may be some question as to the validity of assuming a 20-percent reduction in consumption with individual metering. The percentage reduction would depend to a large extent on the customer's level of affluence and his ability, or inclination, to pay a high electrical bill. The experimental data base on which an estimate of 20 percent was based is admittedly somewhat limited. However, it is felt that this estimate of the potential for savings is reasonable and perhaps conservative.

(3) Energy Savings

An estimate of potential savings from a metering change at one base, Pensacola, was obtained as follows. (Pensacola was chosen since electricity consumption data were more complete than those at Great Lakes.) From Table IV-3, one obtains:

- Average electricity used per unit = 16,000 kWh per year
- Average electricity used per square foot = 13.55 kWh per year
- Number of housing units = 600
- Total electricity used by all housing = 9600 MWh per year.

Two projected reductions in electrical consumption were postulated based on the preceding discussion:

- Case 1—a decrease of 10 percent: that is, 960 MWh per year

- Case 2—a decrease of 20 percent: to reduce average family unit consumption to 12,000 kWh per year. This level is much closer to the average for the city of Pensacola (10,600 kWh per year) and gives a total savings of 1920 MWh per year for the base.

(4) Additional Impacts

The following factors must be considered in measuring the overall impact of the electrical metering strategy:

- Reduction in electricity use means conservation of fuels burned to generate that electricity and thus reduced air pollution levels at generating stations
- More efficient use of electricity with a minimum change in the personal usage patterns of the consumer
- Institutional changes are required to permit billing by housing unit and these may cause some short-term adjustment difficulties.

4. ECONOMIC ANALYSIS

(1) Benefits at Pensacola

The economic benefits of the energy savings postulated in the previous section are presented below. It is assumed that the only benefit is the savings in electricity. If B(t) is the benefit as a function of time (t), then

$$B(t) = \Delta E \cdot C_e(t) = \Delta E \cdot C_e \, e^{q_e t}$$

where $C_e(t)$ is the cost of electricity, which is assumed to increase exponentially at the rate q_e. C_e is the price per unit of electric energy in the first year. The electric energy saved per

year is ΔE. The two alternative energy savings postulated previously were $\Delta E = 960$ and $\Delta E = 1920$ MWh. Benefits accumulated over T years at a discount rate of r are then found to be

$$B = \Delta E \cdot C_e \cdot \left[\frac{e^{T(q_e - r)} - 1}{q_e - r} \right]$$

For parameter values of:

$r = 0.0952$ = discount rate approved by OMB

$C_e = \$.0163/\text{kWh}$ = present price of electricity

$q_e = 0.75\% = 0.0075$ = rate of increase of price of electricity per year

$T = 16$ years = time period,

the benefits can be calculated from the above equation and the results are summarized in Table X-5.

Table X-5
Benefits of the Metering Strategy at Pensacola

Cases		ΔE kWh/yr	Percent Reduction	Savings	
				First Year	To 1990*
Per Household	Case 1	1,600	10	$ 26	$ 224
	Case 2	3,200	20	52	448
Whole Base	Case 1	960,000	10	15,648	134,600
	Case 2	1,920,000	20	31,296	269,200

* In 1973 dollars.

(2) Costs at Pensacola

The general cost function appropriate to this strategy is:

$$C(t) = C_o \, \delta(t) + C_r(t)$$

where C_o is initial capital expenditure and $C_r(t)$ are the recurring costs. The following assumptions were made as to cost per housing unit:(4)

WHAT DOES it cost the util. co. to do this ?

???

- Meter cost (installed): \$30
- Meter reading charge: \$1.87 per meter per year
- Billing charge: \$3 per year (\$.25 per month)
- Miscellaneous overhead expenses: \$3 per year
- Total annual recurring charge: \$7.87.

If labor and billing charges increase exponentially, recurring costs (labor and billing charges) in current dollars can be expressed as

$$C_r(t) = C_r e^{q_o t}$$

Thus, for this strategy

C_r = \$7.87 (current annual recurring costs)

q_o = .035 (taken equal to the estimated annual increase in real GNP).

The total cost accumulated over T years at discount rate r is then given by:

$$C = C_o + C_r \cdot \left[\frac{e^{T(q_o - r)} - 1}{q_o - r} \right]$$

For parameter values of:

r = .0952

C_o = \$30

C_r = \$7.87

q_o = .035

T = 16 years,

the total cost per housing unit over 16 years is computed to be $111 and the total cost for the base (600 units) is $66,600, all in 1973 dollars.

(3) Net Benefits at Pensacola

The net benefits are obtained from the difference between discounted costs and the discounted benefits. The year in which accumulated benefits pass accumulated costs (the improvement has paid for itself) can be found by equating the expressions for costs and benefits. A summary of the economic analysis results is given in Table X-6.

Table X-6
Cost/Benefit Results for the Metering Strategy Applied at Pensacola

Percent Electricity Reduction Assumed	Case I 10%	Case I 20%
Energy Savings Per Year, Million kWh	0.96	1.92
Present Value of Program Cost, in 1973 Dollars	66,600	66,600
Net Benefit, in 1973 Dollars	67,400	202,400
Benefit/Cost Ratio	2/1	4/1
Breakeven Point, Years	1.7	0.7

(4) National Extrapolation

The benefits (both energy and economic) and costs associated with the proposed metering change have been determined for the base at Pensacola. To extrapolate to the rest of the Navy's CONUS bases, the following data were used:

- Number of family housing units (Navy-wide)(2): 85,000

- Total floor area of family housing[2]: 107,500,000 square feet

- Average square feet per unit: 1265 (at Pensacola it was 1800 square feet).

There is no way to determine exactly how much electricity is consumed by family housing Navy-wide. Thus, [illegible] kWh was used as an estimate of the average annual consumption per Navy household. In an absolute sense, this estimate is not critical for the following reasons:

- The percentage reductions resulting from the proposed metering charge are only estimates.

- The overall desirability of the strategy is not affected by small changes in the amount of annual electricity savings, because the changes pay for themselves in such a short time.

The postulated 10- and 20-percent electrical reduction cases, when extrapolated from the Pensacola results to the entire Navy using the above scaling parameters, give the results shown in Table X-7.

Table X-7
Net Benefits to the Navy from the Metering Strategy

Percent Electricity Reduction	Case 1 10%	Case 2 20%
Energy Savings Per Year, Million kWh	85	170
Energy Savings as Percentage of Navy Electricity Consumption in kWh/yr.	1.2	2.4
Program Cost, in Millions of 1973 Dollars	9.43	9.43
Net Benefit, in Millions of 1973 Dollars	2.47	14.37
Benefit/Cost Ratio	1.3/1	2.5/1
Breakeven Point, Years	3.4	1.2

It is clear from these results that, if the anticipated reductions in usage of electricity occur when metering is installed, significant energy and dollar benefits can be realized.

5. IMPLEMENTATION RECOMMENDATIONS

The results of the above strategy analysis indicate that a modification to individually metered systems would provide the Navy with substantial economic savings in a relatively short period of time. The implementation program would be a straightforward one, provided that the administrative and legal obstacles discussed previously could be overcome. One approach to overcoming the legal problems is to sell only electricity produced in naval facilities and to use purchased electricity for all other applications.

The strategy could probably best be implemented in a base-to-base manner; following a brief construction period during which all the meters were installed, an entire base could make the change at one time. Perhaps the most effective way to implement the approach is to conduct a small number of demonstration programs on selected bases to measure the behavioral responses to metering and billing before attempting to expand this strategy to all Navy bases. The attractiveness of such a metering program is clearly not limited to electricity; natural gas and, in some cases, fuel oil could also be metered.

Another well publicized energy conservation technique described in current literature is group demand metering. Every household, by virtue of individual metering, is tied automatically into a central demand monitoring system to gauge the average demand. Then, if one household exceeds the average demand by a certain amount, appropriate corrective measures can be taken. It is possible that the proposed metering changes can be incorporated into such a program and doing so would have many clear-cut advantages.

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO CALIFORNIA 92152

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ENERGY CONSERVATION ATTITUDES AND BEHAVIORS OF NAVY FAMILY HOUSING RESIDENTS

NPRDC Special Report 79-23 July 1979

ENERGY CONSERVATION ATTITUDES AND BEHAVIORS OF NAVY FAMILY HOUSING RESIDENTS

Michael White
Paul Magnusson
E. P. Somer

Reviewed by
Robert Penn

Approved by
James J. Regan
Technical Director

Navy Personnel Research and Development Center
San Diego, California 92152

FOREWORD

This study was conducted as the first stage of a three-stage project sponsored by the Naval Facilities Engineering Command. The objective of the project is to provide Navy management with strategies for use in formulating energy conservation policies to encourage energy conservation by residents of Navy family housing units. The purpose of this study was to assess residents' attitudes, perceptions, values, and knowledge of energy conservation practices. Results will be used in making policy decisions concerning such practices in Navy family housing, and in designing experimental approaches to decrease residents' energy consumption.

In Stage II, the experimental approaches devised from this study will be evaluated. In Stage III, the most promising of those approaches will be tested and evaluated using a larger sample and extending the effort over a long period of time.

We express our appreciation to the staffs of the local housing offices in San Diego, Port Hueneme, and Point Mugu, CA; Whiting Field, FL; Whidbey Island, WA; and Great Lakes, IL for their cooperation in distributing the questionnaires used in this study.

DONALD F. PARKER
Commanding Officer

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SUMMARY

Problem

The General Accounting Office has estimated that residents of military family housing use 30 to 50 percent more energy than civilian residents of similar housing. In an attempt to curb this trend, Congress has mandated the installation and trial of a mock billing system designed to provide housing residents with monthly feedback concerning their energy use and overuse. Results of previous research on energy conservation have indicated that such delayed feedback is unlikely to bring about the desired savings. Thus, alternative approaches to reducing energy consumption must be tested.

Purpose

The purposes of this study were (1) to obtain information on the attitudes, perceptions, commitment, values, and knowledge of Navy housing residents concerning energy and energy conservation practices, and (2) to determine relationships between conservation behaviors and other variables. Information obtained will be used to design experimental approaches intended to decrease residents' energy consumption.

Approach

A questionnaire was developed and administered to Navy housing residents at San Diego, Point Mugu, and Port Hueneme, CA; Whiting Field, FL; Whidbey Island, WA; and Great Lakes, IL. It included items that assessed demographics, life-styles, housing satisfaction, experience with energy shortages, attitudes and opinions about the energy situation, energy-wasting problems in housing units, knowledge of energy principles, and past, present, and future energy conservation practices.

Responses were analyzed by location to determine differences among respondents living in differing climates. Also, responses to items measuring conservation attitudes were related to responses to items measuring other variables.

Results

Only 16 percent of the respondents agreed that there is no real shortage of energy, while 69 percent agreed that we are facing a long-term energy shortage. Most respondents feel that conservation can improve the situation, and think of themselves as energy conservers. Also, most reported that they would put conservation before personal comfort, although this tendency is not as strong in locations with harsh winter weather.

Both positive and negative economic incentives to conserve were endorsed by better than two to one margins. Also, a surpisingly large number of respondents did not agree that people who pay for their own utilities use less energy than people who do not.

Generally, respondents were much more likely to engage in conservation behaviors that result in direct savings of energy in their own home, such as setting heater thermostats lower and instructing family members about conservation, than in behaviors that would have only indirect effects, such as joining conservation groups and writing letters to publications and government officials. Apparently respondents generally are willing to undertake future conservation actions that require the least effort or cause the least discomfort.

It appears that respondents' present conservation behavior can best be predicted by their past conservation behavior; and their future conservation behavior, by their attitudes toward energy conservation.

Satisfaction with Navy housing is moderately correlated with behavior intentions and energy wasting structural problems observed in housing units. No correlations yielding any predictive value were found between housing satisfaction and past or present conservation behaviors.

Conclusions

Respondents appeared to be uncertain and indecisive concerning the causes of the present energy situation. Of the causes listed in the questionnaire, however, respondents most frequently endorsed profiteering by oil and electric companies and overuse of energy by commerical/industrial users. Although many respondents feel there is a lack of information about the energy situation, a large majority feel well informed about specific household conservation practices.

The age of the service member, pay grade, and length of time in service all seem to be positively associated with increased frequencies of reported energy conservation behaviors. Behaviors also seem to differ by location, with respondents from locations with milder climates reporting higher frequencies of conservation behavior than those from locations with harsher climates.

CONTENTS

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INTRODUCTION

Problem

The General Accounting Office has estimated that military families occupying housing units furnished by the military services use 30 to 50 percent more energy than civilian families occupying similar housing. The fact that occupants of military housing do not pay for their household utilities has prompted Congress to require that individual utility meters be installed in preparation for a mock billing system. Although no payments will be required, residents will be informed of their total monthly energy consumption and the amount, if any, overconsumed based on a standard for their climate and the size of their families and housing units.

The mock billing system is designed to induce occupants of military housing to reduce their energy consumption by providing them feedback concerning their energy use and overuse. Research literature on energy conservation, however, indicates that informational feedback delayed longer than 1 week has not been successful in reducing energy consumption (Seaver & Patterson, 1976; Winett, Kagel, Battalio, & Winkler, 1978); with the mock billing system, feedback would be delayed for as much as a month. Thus, alternative approaches to reducing energy consumption must be tested.

Background

Studies on energy conservation have employed a variety of behavioral techniques. Results showed that use of monetary incentives (Winett & Nietzel, 1975; Kohlenberg, Phillips, & Proctor, 1977), daily or immediate feedback as to energy consumption (Kohlenberg et al. 1977; Seligman & Darley, 1977), and nonmonetary incentives such as social recognition (Seaver & Patterson, 1976) all proved effective in decreasing energy consumption.

Income level has been related to the consumers' general knowledge concerning energy (Morrison & Gladhart, 1976; Newman & Day, 1975), and to their energy conservation behavior. Grier (1976) found that people in middle income groups ($14,000 to $16,999) tend to engage in more energy conservation practices than those in other income groups; and Walker and Draper (1975), that those in higher income groups ($17,000+) adopt more conservation practices than those in the lowest income groups. On the other hand, Morrison and Gladhart (1976) found that people in higher income groups consumed more energy than those in other groups. Thus, it appears that (1) people in middle income groups save the most energy, (2) the conservation practices of those in the higher income groups are offset by their increased consumption, and (3) those in lower income groups, even though they engage in few conservation practices, consume the least energy.

As a group, the people who consider the energy problem as "real" tend to be more highly educated (Warren & Clifford, 1975; Zuiches, 1975), employed in skilled and professional occupations (Thompson & Mactavish, 1976), and more knowledgeable about the energy situation (Gottlieb & Matre, 1976). Surveys conducted to determine how the belief in a "real" energy situation related to reported conservation efforts, however, have not been consistent in their findings. Gottlieb and Matre (1976) and Hogan (1976) found that increased conservation efforts were positively associated with increased belief, while Morrison (1975) and Morrison and Gladhart (1976) found no association.

Some differences as to attitudes concerning the energy situation and conservation practices have been found across age groups. Stearns (1975) found that older respondents expected the energy problem to continue for a shorter period of time than did younger

ones. Talarzyk and Omura (1975) reported that older persons were less resistant to conservation requests, but that the oldest and youngest age groups made the least change in their activities. Young, middle-class adults were more concerned with the quality of life than with material success, tended to incorporate the conservation ethic into a larger value system, and felt that energy conservation could not become effective until social priorities had been realigned (Gallup Organization, 1976).

Although studies have found differences between men and women on measures of energy conservation knowledge and attitudes, findings across studies are contradictory. Gottlieb and Matre (1976) reported that men know more about energy and are more likely to believe in a real energy shortage than do women. In contrast, Zuiches (1975) found that women were more likely to believe in the reality of the energy crisis; and Rappeport and Labaw (1975), that they knew more about energy in areas that are associated with everyday life than men.

Finally, several investigators have examined attitudes regarding causes of the energy situation. Most persons queried blamed the situation primarily on the oil companies (Angell & Associates, 1975; Rappeport & Labaw, 1975; Talarzyk & Omura, 1975; Murray, Minor, Bradburn, Cotterman, Frankel, & Pisarski, 1974). Others blamed it on the public utilities (Angell & Associates, 1975), the Federal Government (Murray et al., 1974), and the tendency for the American people to waste energy (Rappeport & Labaw, 1975). This tendency to see human agencies rather than a limited supply of oil as responsible for the energy situation is negatively correlated with amount of knowledge concerning energy and amount of change in energy consumption life style (Gottlieb & Matre, 1976).

Purpose

The present study represents the first of a three-stage project designed to develop energy conservation procedures for use in lieu of the delayed feedback approach mandated by Congress. The objectives of this first stage were (1) to assess the attitudes, perceptions, commitment, values, and knowledge of Navy housing residents concerning energy and energy conservation practices and (2) to determine relationships between conservation practices and other variables. Data obtained will be used in the experimental applications to be conducted in Stage II of this project, and to provide Navy housing management with information for use in making policy decisions concerning energy conservation.

APPROACH

Questionnaire Development

A survey questionnaire was developed based on results of previous attitudinal and behavioral research studies. It was designed to assess variables found to be related to energy conservation in those studies, plus those that the authors felt were appropriate for the present population and situation.

A copy of the questionnaire is provided in Appendix A. It includes 155 items that cover eight major areas: (1) demographics, (2) life-styles, (3) housing satisfaction, (4) experience with energy shortages, (5) attitudes and opinions about the energy situation, (6) past, present, and future energy conservation behaviors, (7) energy-wasting problems in housing units, and (8) knowledge of energy principles. Pilot administration indicated that it could be completed within 30 minutes.

Survey Administration

Questionnaires and accompanying materials were sent by bulk mail to the local housing offices in Point Mugu and Port Hueneme, CA; Whidbey, Island, WA; Whiting Field, FL; and Great Lakes, IL. Accompanying materials consisted of an optical scanning answer sheet, a postage-paid return envelope, and a cover letter signed by the Assistant Commander for Family Housing within the Naval Facilities Engineering Command. The letter explained the purpose of the survey and requested the cooperation of the military family. At the local housing offices, questionnaire packages were assembled and mailed to all Navy family housing units in the area. At all locations except Great Lakes, mailing was completed prior to 1 April 1978; at Great Lakes, it was completed by the end of April.

In the San Diego area, questionnaire packages were sent directly to half of the Navy family housing units in the area. Residents receiving the package were selected on a random basis. Mailing was completed by 6 March 1978.

A total of 7,247 questionnaires were mailed. By 15 May 1978, the response cut-off date, 3,413 (47%) had been returned. Of those, 203 were sent back as undeliverable, and 450 were discarded because of respondent coding errors. Thus, the total number of usable responses was 2,760 (38% of the total mailed).

Analyses

Responses were analyzed by location to identify any differences among respondents living in differing climates. Also, responses to items measuring conservation attitudes were cross tabulated with those to items measuring overall satisfaction with housing and other variables to determine if any relationship existed. Finally, scores representing major sections of the questionnnaire were intercorrelated.

RESULTS AND DISCUSSION

Survey Responses

A major interest in the design of this survey was to investigate possible differences in energy use and conservation attitudes and practices among Navy family housing residents in different climates. Thus, the survey questionnaire was administered in six locations selected to represent moderate and severe climatic conditions in which concentrations of family housing units are situated. When the questionnaire responses were tabulated separately for each of the locations, however, the response pattern for most of the items showed little difference across climatic locations. Therefore, the following discussion will focus on the combined responses from all the locations. Where apparent differences do exist between locations, they will be noted. The tabulations for all items are provided in Appendix B.

Demographics

Items 1 through 17 dealt with demographics/background characteristics. The first 10 concerned the background characteristics of the service member in whose name the housing unit was assigned. Results are summarized below:

1. Over 98 percent of the service members were male.

2. Overall, enlisted personnel outnumbered officers by better than four to one (82 vs. 18%). This ratio of enlisted/officer personnel was about 3:1 at Port Hueneme and Whidbey Island and 3:2 at Whiting Field.

3. About 43 percent of the service members were high school graduates or equivalent but with no college, while 35 percent had completed some college but received no degree. Thirty-four percent of the service members at Whiting Field had bachelor's degrees, and 14 percent at Port Hueneme had master's degrees.

4. The service members' types of duty assignments differed among locations. At San Diego, the ratio of ship/shore duty was about 1:1. At the other locations, from 82 to over 99 percent were assigned to shore duty.

5. There were also considerable differences among locations as to the proportions of service members currently deployed or living away from home. At Great Lakes and Whiting Field, the proportions were 1 and 3 percent respectively, compared to 31 percent at Port Hueneme.

6. Items 6 and 7 asked respondents how long the service member had been away from home and how long it would be before he returned. The number of responses to these items should have corresponded to the number of service members identified as deployed or away in item 5. Because the number did not correspond, and because there were so few responses to these items, they were not included in the analysis.

7. Items 8 and 9 concerned length of service and age respectively. One third of the service members had 8 or less years of service; and two-thirds, from 9 to 20+ years. In regard to age, overall, 47 percent were between 31 and 40 years of age; and 29 percent, between 26 and 30. Whidbey Island and Whiting Field had greater proportions of junior personnel—in regard to both years of service and age—than the other locations.

8. Finally, item 10 concerned pay grade. The highest percentage (38%) of enlisted were E-6s (petty officers first class) and the highest percentage (26%) of officers were 0-3s (lieutenants). The pay distributions at Whidbey Island and Whiting Field were

consistent with the age and length of service patterns at those locations. Both had more E-4s (petty officers third class) and below and 0-2s (lieutenants junior grade) and below than elsewhere. The proportion of 0-1s (ensigns) at Whiting Field--over 20 percent--was particularly noteworthy. In contrast, Point Mugu had a very small proportion of 0-1s and 0-2s and a relatively large group of 0-4s (lieutenant commanders) (41% of the officers there).

Items 11 through 14 were to be completed only if the respondent was someone other than the service member. Based on the varying numbers of responses to these items, it appears that between 47 to 49 percent of the questionnaires were completed by nonservice members. Of these, 94 percent were female; and 99 percent, spouses. Consistent with the ages of the service members, the ages of the spouses tended to be lower at Whidbey Island and Whiting Field and higher at Port Hueneme than at the other locations. Somewhat fewer spouses than service members had college degrees. As with age, however, the education levels of the spouses appeared to be related to those of the service members; that is, the proportions of spouses with bachelor's degrees were highest at Whiting Field, Port Hueneme, and Whidbey Island.

In response to Item 15, which concerned service members' race, 88 percent overall indicated that they were white, with San Diego and Port Hueneme having more nonwhite respondents than the other locations. Finally, in response to item 16, which concerned climatic conditions where respondents grew up, the largest proportion (62%) indicated that they grew up in areas with hot summers and cold winters.

Item 17 asked respondents to indicate the location of their present housing. When responses to this question were correlated with those to item 16, a pattern of similarity emerged as to climatic conditions where respondents grew up and where they were stationed. That is, relatively large proportions of San Diego, Point Mugu, and Port Hueneme respondents grew up in areas without distinct seasons; Great Lakes respondents, with cold winters and hot summers; Whidbey Island, with cold winters and mild summers; and Whiting Field, with hot summers and mild winters. There are at least two possible explanations for this pattern. First, Navy members may tend to be assigned to the same areas where they grew up, either as an economy measure to save travel costs or in response to their stated preferences. Second, some respondents may have misread item 16, thinking that it referred to the weather in their present, rather than childhood, location.

Present Housing Situation

Items 18 through 23 concerned the respondents' present housing situation. Responses to item 18 indicated that, overall, 54 percent had lived in their residences for over a year. The response alternatives to item 19 are rather technical descriptions of the type of housing unit occupied (e.g., capehart or appropriated fund). Thus, it is not surprising that only about 70 percent of the residents responded to this item. These responses, and those to item 20, which concerned various housing unit types, reveal considerable differences by location. That is, the largest proportions of respondents at Point Mugu, Whidbey Island, and Whiting Field lived in single houses; at Great Lakes, in row or townhouses, and at Port Hueneme, in duplexes. San Diego respondents were fairly equally represented among the four housing unit types listed.

Responses to item 21, which asked how many persons lived in the unit for at least 6 months of the year, indicated that, overall, 40 percent of the units had four people living in them. The mean number of residents ranged from 3.6 at Whiting Field to 4.4 at San Diego. Finally, items 22 and 23 asked how many residents reported in item 21 were home

during the evenings or during the day on weekdays. Responses showed that, of the overall average of 4.1 residents, 3.8 were at home in the evenings and 2.1 during the day. As with number of residents, Whiting Field had the lowest mean number at home in the evenings, and San Diego the highest--3.4 vs. 4.1. Port Hueneme had the lowest mean number home on weekdays, closely followed by Whiting Field—1.8 and 1.9. The low mean at Port Hueneme may be because the somewhat older service members and spouses there had more children away in school.

Current and Childhood Life-styles

Items 24 through 26 dealt with respondents' life-styles. In response to item 24, which concerns present life-styles, about 40 percent of the respondents reported that they "can afford all we need"; and an equal number, that they "have to budget carefully to get by." When asked about their life-style during their childhood (item 25), 34 and 30 percent respectively of the responses fell into these two categories. The largest difference between present and past life-styles is seen in the percentages selecting the category stating "can't (couldn't) afford lots of the things we need (needed)." About 7 percent of present responses vs. 18 percent of childhood responses fell into this category. Examination of the response means by location shows that Whiting Field respondents considered themselves the most well off; and San Diego respondents, least well off. Respondents at Whiting Field and Whidbey Island gave the highest rating to their childhood life-styles; and those at Port Hueneme, the lowest. The age differences noted earlier, with Whiting Field and Whidbey Island having the youngest respondents and Port Hueneme, the oldest, may explain these scores. Younger people are likely to have had more economically comfortable childhoods than older people due to the national trend of increasing personal prosperity since the depression years. As to current total family income (item 26), the category most frequently reported by the respondents is $10,000 to $12,999 per year. Residents of Whiting Field, Whidbey Island, and San Diego had the lowest mean income; those of Great Lakes and Point Mugu stood in the middle; and those at Port Hueneme had the highest mean income. Curiously, some elements of the relationship between present income and present reported life-style are the reverse of what might be expected. For example, Whiting Field had the lowest mean dollar income and the highest mean present life-style score, while Port Hueneme had the highest mean income and the second lowest life-style score.

Housing Satisfaction

Items 27 through 35 asked respondents to indicate how satisfied or dissatisfied they were with various aspects of Navy housing. Responses were to be made on a five-point scale, ranging from very dissatisfied to very satisfied. Table 1 provides a breakdown of the results across locations. For convenience, the scale was collapsed to three points: dissatisfied, neutral, and satisfied.

Responses to item 34, which measured respondents' overall satisfaction with Navy housing indicated that, overall, 60 percent of respondents were satisfied. The only location where the proportion was lower than that was Great Lakes, where only 48 percent were satisfied, and 26 percent, dissatisfied.

Similarly, responses to items 27 and 28 showed that fewer Great Lakes respondents were satisfied with the inside and outside appearances of their housing than were respondents from other locations combined (58 and 43% vs. 74 and 59%). Further, responses to items 29 and 30 showed that fewer Great Lakes respondents were satisfied with housing remodeling regulations and distribution than were respondents from the other locations combined (25 and 32% vs. 37 and 43%).

Table 1

Housing Satisfaction by Location

	Item	San Diego (%)	Great Lakes (%)	Pt. Mugu (%)	Port Hueneme (%)	Whidbey Island (%)	Whiting Field (%)	Total (%)
27.	Appearance of the inside of housing.							
	Dissatisfied	11.1	21.3	11.2	13.4	6.1	7.8	13.5
	Neither satisfied nor dissatisfied	14.1	21.0	14.7	20.9	15.6	17.3	17.1
	Satisfied	74.9	57.6	74.2	65.8	78.4	74.9	69.5
28.	Appearance of the outside of housing.							
	Dissatisfied	21.5	37.9	20.7	23.5	30.3	14.2	24.7
	Neither satisfied nor dissatisfied	18.8	18.9	20.7	17.6	19.7	18.8	19.1
	Satisfied	59.6	43.3	58.6	58.9	50.0	67.0	56.2
29.	Remodeling regulations.							
	Dissatisfied	30.8	43.2	25.3	24.7	24.9	16.7	32.0
	Neither satisfied nor dissatisfied	35.8	31.9	39.5	37.4	40.1	41.9	36.0
	Satisfied	33.3	24.9	35.2	37.9	35.1	41.4	32.0
30.	Housing distribution.							
	Dissatisfied	34.3	41.1	36.0	34.0	23.6	25.1	34.6
	Neither satisfied nor dissatisfied	27.2	26.4	26.0	25.8	27.2	26.7	26.7
	Satisfied	38.5	32.5	38.1	40.1	49.2	48.1	38.7
31.	Housing maintenance and repair service.							
	Dissatisfied	22.3	23.2	29.4	22.1	14.0	15.1	21.7
	Neither satisfied nor dissatisfied	16.9	16.8	15.2	11.3	13.4	12.0	15.6
	Satisfied	60.8	59.9	55.4	66.6	72.6	72.8	62.7
32.	Quality of area of housing.							
	Dissatisfied	11.5	21.2	7.8	10.7	9.0	10.5	13.7
	Neither satisfied nor dissatisfied	14.6	22.5	13.4	13.3	8.9	12.0	15.9
	Satisfied	74.0	56.3	78.7	76.0	82.1	77.5	70.4
33.	Size of housing relative to need.							
	Dissatisfied	17.9	24.0	15.1	20.9	15.9	13.6	19.2
	Neither satisfied nor dissatisfied	8.6	8.4	9.5	5.9	6.1	5.8	7.9
	Satisfied	73.4	67.6	75.4	73.3	78.1	80.6	72.9
34.	Overall rating of housing.							
	Dissatisfied	14.9	26.3	9.9	13.5	15.9	9.4	17.5
	Neither satisfied nor dissatisfied	20.8	25.7	19.8	26.5	19.1	15.7	22.0
	Satisfied	64.3	48.1	70.2	60.0	64.9	74.9	60.5
35.	Availability of housing.							
	Dissatisfied	76.2	54.0	58.0	50.0	37.9	43.7	59.4
	Neither satisfied nor dissatisfied	11.0	19.4	18.6	20.4	18.8	17.4	16.2
	Satisfied	12.7	26.6	23.3	29.6	43.3	38.9	24.4

The only other substantial difference between locations is in regard to satisfaction with housing availability (item 35). More respondents from San Diego were dissatisfied with the availability of housing than were the rest of the sample (76 vs. 49%).

Experience with Energy Shortage

Item 36 asked respondents whether they or members of their family had experienced a shortage of natural gas or electricity. Relatively few—only about 14 percent--of the respondents answered "yes" to this question. Item 37 asked these respondents to indicate how the experience had affected them. Overall, 41 percent reported that it convinced them that there is a real need to conserve energy and that they try to conserve as much as possible. Only 5 percent were not convinced by their experiences that an energy crisis exists and stated that they do not intend to change their attitudes or behaviors.

Unusual Conditions Affecting Household Energy Consumption

Item 38 asked respondents to indicate any unusual condition that might be causing them to use more electricity or heating fuel than usual. Overall, 51 percent reported that they were experiencing no such condition; and 19 percent, the presence of an infant family member. (Thirty percent of Whiting Field respondents reported the presence of an infant, which is consistent with the large number of young service members and spouses there.)

Respondents who selected the open-ended "other" response category frequently indicated that unusually cold winter weather and weather-connected problems with housing units, such as drafts and insufficient insulation, caused them to use more fuel. It is not surprising, then, that the largest proportions of respondents choosing this category were from Great Lakes and Whidbey Island, the two locations with the most severe winters.

Attitudes and Opinions About Energy Situation

Items 39 through 70 were included to assess attitudes toward and opinions on the energy situation. Responses to these items were made on a five-point scale, ranging from "Strongly agree" to "Strongly disagree." It is interesting to note that, for 27 of the 32 items, from 20 to 56 percent of the respondents selected the "Neither agree nor disagree" category. It seems likely, however, that respondents selecting this category included those who had no opinion or were uncertain about their answer, as well as those having neutral opinions. In the following paragraphs, responses to related groups of items will be discussed.

Seriousness of the Energy Situation (Items 39, 40, 47, 48, 53, 58, 62, 63, and 70). Overall, 47 percent agreed that there is a real shortage of energy, and 16 percent disagreed (item 63). More Whiting Field and Whidbey Island respondents felt the shortage was real than did those at other locations combined (55 and 57% vs. 46%). Overall, 69 percent agreed that "Regardless of the cause, we are facing a long-term energy shortage," and 10 percent disagreed (item 47). The pattern of responses to these two items indicates that many respondents felt that the energy situation will become more serious than it is now. Most felt, however, that the present energy situation is sufficiently serious to call for changes in behavior: conserving more and changing our way of life. Respondents also tended to believe that conservation can improve the situation, as shown by the percentages who agreed to the following statements:

1. "There would be enough energy if everyone quit wasting it" (item 62)--45 percent who agreed vs. 18 percent who disagreed.

2. "The present energy situation could be eased through conservation in the home" (item 48)--63 vs. 14 percent.

3. "We will have sufficient energy if we develop and adopt more efficient energy saving devices" (item 58)--63 vs. 12 percent.

The apparent faith in technology shown in the response to item 58, however, does not extend to the development of new energy sources. A whopping 56 percent neither agreed nor disagreed that "Technological discoveries will provide all the energy we need long before our present sources run out" (item 70). The rest of the respondents were about evenly divided between agree and disagree (23 and 20%), with only 18 percent of Whidbey Island respondents agreeing. Clearly, few respondents felt that the discovery of new sources will solve energy problems. Nonetheless, most appeared to feel that it is still worthwhile to go on looking for new energy sources: Overall, 50 percent agreed (vs. 14% who disagreed) that "The Federal Government is not doing enough to find and develop new energy sources" (item 53). Fewer Port Hueneme respondents agreed with this statement than did those in other locations combined (42 vs. 52%).

<u>Personal Commitment to Conservation</u> (items 40, 41, 43, and 60). Respondents generally appear to be personally proconservation. Overall, 72 percent agreed that "I think of myself as an energy conserver" (item 43), while only 4 percent disagreed. Somewhat more San Diego residents agreed and more Port Hueneme residents <u>strongly</u> agreed than did those in the other locations.

Overall, 60 percent agreed that "We should all change our way of life so that we can live with the present energy situation" (item 40), which confirms the proconservation interpretation. Further, 65 percent disagreed with a statement indicating that they would <u>not</u> be willing to adjust their thermostat if it made them uncomfortable in any way (item 41); and 68 percent, that their own personal comfort was more important to them than saving energy (item 60). Proportionately more respondents from Great Lakes, however, <u>agreed</u> with these statements than did those from the other locations combined (22 vs. 14% for item 41, and 12 vs. 8% for item 60).

<u>Causes of the Energy Situation</u> (items 44, 52, 54, 55, 57, 62, 64, and 68). The responses to items concerning causes of the energy situation are presented in Table 2. As shown, about a third of the respondents indicated that they neither agreed nor disagreed with the statements, which reflects considerable uncertainty or indecision as to the causes of the situation.

Overall, 55 percent agreed with the statement in item 57, which blames oil and electric companies for the energy situation. This result is disquieting to those trying to foster energy conservation, since Navy family housing residents who share this belief are unlikely to take appeals to conserve energy seriously. The response to item 54 also appears noteworthy in this regard. It may be, however, that only 21 percent agreed that "we are really running out of oil" because they misinterpreted the meaning of the statement. For example, many respondents may have disagreed because they felt the statement meant that running out of oil was imminent. These individuals may well have believed that our oil supplies are adequate for present but not for future needs. This interpretation would support the conclusion reached based on responses to items 47 and 68 (page 9); that is, that most respondents felt that the energy situation is getting worse.

Table 2

Items Relating to Causes of Energy Situation

Item	Mean Score[a]	Agree (%)	Disagree (%)	Neither Agree nor Disagree (%)
57. Profiteering by oil and electric companies is largely responsible for the present energy situation.	1.37	55	11	34
68. Overuse of energy by commericial/ industrial users is a major cause of the present energy situation.	1.39	55	10	35
55. Depending too much on oil as an energy source has caused the present energy situation.	1.44	59	13	28
52. Environmentalists' interference in the development of other energy sources has made the energy situation worse.	1.62	45	20	35
62. There would be enough energy if everyone quit wasting it.	1.66	45	18	37
44. Foreign oil prices and restrictions are largely responsible for the present energy situation.	1.86	41	33	26
54. We are in the present energy situation because we are really running out of oil.	2.25	21	41	38
64. Wasteful use of energy in the home is to a large extent responsible for the energy situation.	2.35	20	47	33

[a]Based on a five-point scale where 0 = strongly agree, 2 = neither agree nor disagree, and 4 = strongly disagree.

Table 2 also includes response means computed to make differences in proportions of respondents who agreed and disagreed with these items more apparent. Mean scores of less than two indicate agreement; and those of more than two, disagreement. Although the items in Table 2 are listed in order of decreasing agreement, the table should not be interpreted as a rank ordering of causes of the energy situation. Because of the differences in item wording, the items are not directly comparable.

Adequacy of Information (items 39, 49, 50, 51, and 56). Overall, 52 percent of the respondents agreed that people would conserve more energy if they knew more about the energy situation, vs. 26 percent who disagreed (item 39). This implies a lack of information or knowledge, at least on the part of "others." Although 46 percent agreed that they feel well informed about the energy situation (item 49), 48 percent still felt that "Information that we have a right to know is being withheld from us" (item 56). While many respondents apparently felt there is a shortage of information about the energy situation as a whole, 80 percent felt that they are well informed about specific household energy conservation practices (item 50). Only 40 percent, however, agreed that knowing how much energy they consumed daily would help them to conserve, vs. 32 percent who disagreed. More respondents at Whidbey Island and Whiting Field agreed with this latter statement than those in other areas (47 and 50% vs. 38%).

Energy Situation Economic Issues (items 56, 66, 67, and 69). Respondents endorsed both positive and negative economic incentives to conserve. Overall, over half agreed that (1) rewarding people who use less energy would promote energy conservation (item 65), (2) people who use devices that conserve energy should get a tax break (item 67), and (3) people who use too much electricity should have to pay more for it (item 66). More Great Lakes and Whiting Field residents disagreed with this last statement than did the other residents combined (28 and 29% vs. 22%), probably because the harsh weather at these locations causes them to use more energy. Finally, 44 percent agreed that people who pay for their own utilities use less energy than those who don't (item 69), while 31 percent disagreed. This issue is probably clouded by respondents' self-interest. Disagreement might possibly be seen as resistance to changing the policy of not billing family housing residents for their utilities.

"Military" Issues (items 42, 45, 46, and 61). Most respondents appear to have negative feelings about pay and benefits. Overall, only 24 percent agreed that "The military member in my family is being fairly paid for his/her work," while 62 percent disagreed (item 46). Further, an overwhelming 91 percent agreed that "Military benefits are steadily being taken away with nothing given back to replace them" (item 45).

Only 13 percent of the respondents agreed that military family housing residents conserve more energy than civilian families, while 48 percent disagreed (item 42). Further, only 22 percent agreed that their neighbors try to conserve energy compared to 22 percent who disagreed and 56 percent who neither agreed nor disagreed (item 61). Thus, it appears that respondents did not feel their neighbors are as committed to conservation as they are themselves.

Importance of the Energy Situation

Respondents were presented with a list of nine topics considered to be of national importance, including the energy situation, and asked to indicate the topic they considered first, second, and third most important (items 71, 72, and 73 respectively). Results showed that the majority from each location chose "inflation and the economy" as the most important topic. Depending on the location, either "crime" or "the energy situation" was selected next most frequently as the most important. Neither of these topics, however, was selected by more than 20 percent of the respondents from any area.

The energy situation was most frequently selected as the second most important topic by respondents in all areas except those at Port Hueneme, who selected "crime." It was also most frequently selected as the third most important topic by respondents in all areas, except those at San Diego, who chose "unemployment." As shown in Appendix B (pp. B-25/26), there was much less respondent agreement as to the second and third most important national topics than there was for the most important one. No more than 35 percent of the respondents at any one location and 28 percent overall selected any one topic as the second or third most important.

Although respondents did not consider the energy situation the nation's most important problem, they did consider it one of the most important of those presented, ranking below "inflation and economy" and slightly above "crime" and "unemployment." There was less agreement among respondents concerning the relative importance of the energy situation, however, than there was for "inflation and economy." Also, it should be noted that these item responses may have been influenced by the fact that the items were included in a questionnaire focused on the energy situation. Exposure to the other items concerning energy, coupled with the obvious demand characteristics of the items in question, may have increased the respondents' sensitivity to the topic.

Past Energy Conservation Behaviors

Items 74 through 87, which were included to obtain information on respondents' past energy conservation practices, comprised a list of general energy conservation practices. Respondents were to indicate whether or not they had participated in them, if applicable.

Results showed that, overall, 86 percent had instructed their families about energy conservation, 74 percent had talked with their friends about the energy situation, and 72 percent had tried to learn more about energy conservation practices (items 74, 75, and 76). In regard to household practices, 50 percent had set their refrigerator thermostat to a warmer setting, 72 percent had replaced light bulbs with lower wattage ones, and 60 percent had lowered their water heater thermostat (items 80, 82, and 86). Although only 29 percent had air conditioners, two-thirds of those reported that they had set them no lower than 78 degrees (item 78).

On the other hand, only 3 percent had signed a petition on energy conservation, 5 percent had participated in a group promoting energy conservation, and 17 percent had attended a meeting on energy conservation (items 77, 79, and 81). Only 3 percent had written to a government agency concerning the energy situation; and 2 percent, to a publication (items 83 and 85). Finally, only 25 percent had supported energy conservation legislation, and 17 percent, a political candidate for his/her stand on the subject.

These findings indicate that, overall, respondents were much more likely to have engaged in conservation behaviors that affect them directly, such as reducing light bulb wattage and lowering thermostats, than those that indirectly affect the general situation, such as writing to a government agency. It may be, however, that respondents simply did not have the opportunity to engage in many of the behaviors listed.

Responses to only two of these items differed significantly across locations. Fifty-five percent of respondents from San Diego reported setting their refrigerator thermostat to a warmer setting, compared to an average of 45 percent in the other locations combined (item 80). Also, 42 and 40 percent of Whidbey Island and Whiting Field respondents respectively reported lowering their water heater thermostat, compared to 60 percent of the overall sample.

Present Energy Conservation Behaviors

Items 88 through 119 were included to measure respondents' present activity in 29 energy-related behaviors. Responses were based on a five-point subjective frequency scale, ranging from "All the time" to "Never," with a sixth option, "Does not apply." While the responses indicated that respondents often participated in conservation behavior, it should be remembered that these are self reports that may not reflect actual behavior.

Household Heating and Cooling. Overall, 52 percent of the respondents reported that they keep their heater thermostats below 68 degrees F all or most of the time (item 90); 68 percent, that they keep windows closed with heaters or air conditioners on (item 91); and 78 and 64 percent, that they turn their heaters down when no one is home and before going to bed at night all or most of the time (items 96 and 107).

Across locations, some differences can be noted. More people from San Diego and Port Hueneme (27 and 30% respectively) reported that they keep their heater thermostats at 68 degrees or less all of the time than the rest of the sample combined (19%). More Whiting Field respondents reported keeping their windows closed while heating or air conditioning is on than the remainder of the sample (82 vs. 67%), although fewer of them reported turning their heaters down all the time before going to bed at night than those from other locations (29 vs. 44%).

Laundry and Dishwashing. Overall, 50 percent of the respondents reported that they wash only full loads of laundry (item 88). Of the 60 percent that use a dishwasher, two-thirds of those reported that they never run it when it is only partially full. Forty-six percent reported that they never run their clothes washer when only partially full, and another 46 percent, that they run it some of the time when only partially full (item 106). When asked how often they wash their clothes in cold water, 7 percent reported never; 31 percent, either all or most of the time; and 34 percent, some of the time (item 119).

Cooking and Food Preparation. Overall, 61 percent reported preheating their ovens unnecessarily either once in a while or never; 79 percent, using cooking time all or most of the time to determine if food is done; and 69 percent, never leaving the refrigerator door open unnecessarily (items 109, 116, and 118).

Miscellaneous Areas. Other significant energy conservation behaviors were reported. For example, respondents reported taking shorter, colder showers than in the past, reducing the number of electric lights burning at once, and often reminding family members to conserve energy.

Future Energy Conservation Behaviors

To obtain information on future energy conservation behaviors, respondents were presented with a list of conservation actions (items 120 through 130) and asked to indicate those that they were willing to take in the future. Table 3, which presents these actions in the order of respondents' indicated willingness, shows that most respondents were generally willing to take actions that cause the least amount of effort or discomfort. Overall, 77 percent said that they were willing to limit their use of energy for heating, an action that could save significant amounts of fuel (item 125). This optimistic finding is tempered somewhat, however, by the fact that fewer respondents at colder locations, where energy use is heavy, were willing to take this action than those at warmer

Table 3

Items Relating to Future Conservation Behaviors Ordered by Respondents' Decreasing Willingness to do Them

Item	Conservation Action	Percentage Willing to do Them
122.	Instruct and remind your family about energy conservation.	98.2
120.	Read informational literature about the energy situation.	95.9
127.	Replace light bulbs with bulbs of lower wattage.	89.1
129.	Wash clothes in cold water most of the time.	78.9
125.	Shut off your household heating except on cold days (below 65 degrees F).	76.8
123.	Participate in an experiment in which you would receive money or gifts for conserving energy.	75.5
130.	Turn down heater thermostat to 65 degrees F.	70.2
121.	Support a political candidate for his/her strong support of energy conservation.	62.1
124.	Support energy conservation legislation even though it might raise your taxes slightly.	48.5
128.	Be part of an experiment in which the names of energy over-users are printed in the local newspaper.	36.5
126.	Shut off your water heater.	10.7

locations. Some measure of commitment to conservation is evidenced by the response to item 124: almost half of the respondents reported that they would support conservation legislation at the expense of a slight tax increase. The difference between an expressed willingness to act and acting itself, however, should not be overlooked.

The responses to items 123 and 128, which deal with potential experimental treatments, are of particular interest for the purposes of later stages of this study. As shown in Table 3, 75 percent were willing to be part of an experiment if they are rewarded for saving energy, but only 36 percent would risk the embarrassment of being identified as overusers.

Energy-wasting Problems in Housing Units

Respondents were presented with a list of potential energy-wasting problems in the design, construction, and maintenance of the military housing units (items 131 through 139), and asked to check those they had noticed in their homes. The problems noted most frequently were uncarpeted rooms (80%), doors and windows that do not close tightly (61 and 50%), and "others" (76%). When a limited random sample of the written-in "Other" responses was tabulated, inadequate insulation and poor construction were most frequently mentioned as energy-wasting problems.

The frequency with which the various problems were reported varies considerably between locations. Doors and windows that do not close tightly appear to be a particular problem at Great Lakes and Whiting Field; cracks in floors, walls, and ceilings, at Great Lakes; dripping hot water faucets, at Whiting Field; and cracked or broken windows, at Whidbey Island.

Knowledge of Energy Principles

To determine how familiar respondents were with energy principles, they were presented with a series of statements about limited aspects of energy production, use, and conservation (items 140 through 151), and asked to indicate whether the statements were true or false. Results showed that most respondents at all locations were familiar with the major principles covered by the questions. Only about a third, however, were familiar with the more technically sophisticated issues (items 147, 149, and 151). Apparently, such issues are less likely to be covered in widely available energy educational materials.

Thermostat Levels

Items 152 through 155 concerned the levels where housing residents set their heating and cooling thermostats during the day and at night. For heating, the most frequently reported levels--for both day and night--were 65 degrees or less, 68 degrees, and 70 degrees, in that order, with night levels being somewhat lower than day levels. To permit easier comparisons, mean temperature settings were computed for each location. Overall, the mean temperature setting was 67.7 degrees, with the three California locations reporting lower mean settings than the three locations with colder winters (66.9 vs. 68.6 degrees during the day, and 66.4 vs. 67.2 degrees at night).

Responses to items 154 and 155 indicate that only two locations--Great Lakes and Whiting Field--provide any substantial number of housing units with cooling systems (25 and 99% respectively). Less than 5 percent of housing units at other locations are so equipped. Overall, the two levels reported most often--for both day and night--were 78

degrees and 76 degrees, with day- and nighttime means of 74.5 and 75 degrees respectively. Consistent with this slightly higher nighttime mean, an examination of the frequency distributions of levels reported indicates that most people raised the thermostats of their cooling systems at night.

Analyses

Relation Between Conservation Behaviors and Other Variables

Responses to the items measuring past and present energy conservation behaviors (Nos. 74 through 87, and 88 through 119 respectively) were cross tabulated with responses to item 34, which measured overall satisfaction with housing. Results showed that such behaviors are not strongly related to housing satisfaction. In regard to past behavior, however, fewer respondents who are "very dissatisfied" had tried to learn more about energy (item 76) or had supported a political candidate for his stand on energy conservation (item 87) than had the rest of the sample. As to current behavior, the few items that do appear to be moderately related are not consistent in the direction of that relation. For instance, a higher proportion of "very dissatisfied" respondents had never run a dishwasher when only partially full (item 93) or used an oven to heat small items (item 94) than the rest of the sample (50 and 78% vs. 42 and 70%). On the other hand, only 41 percent of "very dissatisfied" persons reported reminding their family members to conserve energy at least most of the time (item 99), compared to 51 percent of the rest of the sample.

Responses to the items measuring present energy behaviors also were cross tabulated with responses to items assessing service member's status and age (items 2 and 9) and respondent's sex (items 1 or 11). Results showed that fewer respondents from households where the service member's age is between 18 and 25 reported turning their heat down or off when no one is home (item 96) or reminding family members most or all of the time to conserve energy (item 99) than did respondents from households with older service members (43 and 18% vs. 52 and 27%). There was no relation between the service member's status and present energy behaviors.

Several items, however, seem to be moderately related to respondent's sex: Females responded more positively to items concerning food preparation than did males. For instance, more females reported that they open the refrigerator just once to get items needed for a meal most of the time (item 105) or always set the stove flame to match pot size (item 117) than did male respondents (48 and 64% vs. 35 and 54%). These findings may be due to the fact that females are usually more involved with food preparation than males. Therefore, they are more knowledgeable about the appropriate conservation measures.

Relation Between Overall Conservation Behavior Score and Other Variables

The 32 items assessing current energy conservation behaviors (Nos. 88 through 119) included 16 positive and 16 negative descriptions of energy conservation behaviors. To facilitate comparisons between different groups' behavior, an overall behavior score was computed for respondents by subtracting the mean score for their negative conservation behaviors from the mean score for their positive behaviors. Aggregate scores derived ranged from -5 to +5, with lower scores reflecting more frequent positive and less frequent negative conservation behaviors.

The respondents' aggregate scores were rank ordered and divided into a quartile distribution. Respondents' quartile group membership was then cross tabulated with responses to the other questionnaire items to determine the relationship between overall reported conservation behaviors and other variables. Results are discussed in the following paragraphs. It should be noted, however, that apparent differences discussed are only relative differences in proconservation behavior scores; thus, they may not necessarily reflect great differences in amounts of positive or negative conservation behaviors.

Demographics. The length of time that the service member has been in the Navy (item 8) seems to be positively associated with higher frequencies of energy conservation behaviors. Only 30 percent of the respondents whose service member had been in the Navy 2 years or less were in the top half of energy conservers, compared to 43 percent of those whose service member had served more than 2 but less than 9 years, and 53 percent of those whose service member had served more than 9 years. This variable may be confounded with age, however, since only 36 percent of respondents with the youngest service members (18 to 25) fell into the upper half of energy conservers, compared to 51 percent of respondents with older service members (over 25 years).

Pay grade of service member seems also to be positively associated with conservation behaviors. Only 37 percent of respondents whose service member was an E-4 fell into the top two conservation quartiles, compared to 52 percent whose service member was an E-6, and 53 percent whose service member was an E-8. The same general trend is seen with respondents whose service member was an officer. Forty percent of those with 0-1 service members fell into the top two conservation quartiles, compared to 48 and 52 percent respectively of those with 0-3 and 0-4 service members. It should be noted that pay grade could also be confounded with age of service member and length of time in service because of the high correlation between these variables.

Location. Location of housing (item17), this questionnaire's surrogate for climate, also appears to be associated with energy conservation behaviors. Over half of the respondents in San Diego, Point Mugu, and Port Hueneme, the locations with the mildest weather, have overall conservation scores above the midpoint of the distribution, compared to 44 percent from Great Lakes, 46 percent from Whidbey Island, and 36 percent from Whiting Field.

Dwelling Type and Number of Occupants Per Dwelling. Fewer respondents who live in apartments have high conservation scores than those who reside in other dwelling types (single house, duplex, or town house). The number of people living in the residence also seems to be related to reported energy conservation behaviors. Fewer respondents who reported only one or two people living in their housing have conservation scores falling in the top half of the distribution than do those with more than two living in their housing (44 vs. 54%). This is another variable that may well be confounded with age.

Income. Examination of behaviors by income reveals interesting, if apparently somewhat inconsistent, findings. Present income was measured in two ways: Responses to item 24 were made on a subjective five-point scale, ranging from "Can afford lots of luxuries" to "Can't afford lots of the things we need," while those to item 26 were made on an objective scale reflecting only total yearly income in dollars. The results from item 24 indicate that energy conservation scores increase as perceived economic life-style level decreases. There seems to be no association, however, between these scores and income measured in dollars.

Correlational Analyses of Aggregate Data

For each respondent, aggregate scores of items measuring the major variables were determined. The aggregate scores for items measuring past energy conservation behaviors (Nos. 74-87), future energy behaviors (Nos. 120-130), and housing satisfaction (Nos. 27-35) were computed by simply taking the mean response scores for those items. The score for the items on knowledge of energy principles (Nos. 140-151) consisted of the number of "right" responses. The score for items on present energy conservation behaviors (Nos. 88-119) was computed as described above; that is, by subtracting the mean response score for the negative conservation behaviors from the mean score for the positive conservation behaviors. Similarly, a score was computed for energy conservation attitude items by subtracting the mean response score for the negative attitudes (Nos. 41, 60, and 63) from the mean response score for the positive attitudes (Nos. 39, 40, 43, 47, 48, and 54).

Aggregate scores obtained were used to determine variable intercorrelations, as shown in Table 4. These correlation coefficients represent the data from the entire sample across locations; these data were pooled after the correlational differences across locations were found to be nonsignificant ($p > .05$), as determined using the z test.

The correlation coefficients shown in Table 4 indicate that present energy conservation behavior is most highly related to past conservation behavior, followed by future energy conservation behavior and attitude toward energy conservation. Future conservation behavior as indicated by the respondents is most highly related to attitude toward energy conservation, followed by past and present conservation behaviors.

Housing satisfaction correlates positively with attitude toward energy conservation and energy wasting problems in housing. This indicates that the amount of respondents' satisfaction with their housing tends to be positively associated with proconservation attitudes and with fewer energy wasting structural problems in their housing units. Although housing satisfaction is modestly correlated with future conservation behavior, it is not associated with past or present conservation behaviors.

Table 4

Intercorrelations of Variables Measured by Questionnaire Items

Variable	1	2	3	4	5	6	7
1. Attitude Toward Energy Conservation (Nos. 39, 40, 41, 43, 47, 48, 54, 60, 63)	—	.24*	.28*	.48*	.08*	.08*	.21*
2. Present Energy Conservation Behavior (Nos. 88-119)		—	.46*	.29*	.04**	.06*	.01
3. Past Energy Conservation Behavior (Nos. 74-87)			—	.30*	.11*	-.03	-.01
4. Future Energy Conservation Behavior (Nos. 120-130)				—	.06*	.04***	.13*
5. Knowledge of Energy Principles (Nos. 140-151)					—	.02	.03
6. Energy Wasting Problems in Housing (Nos. 131-139)						—	.31*
7. Housing Satisfaction (Nos. 27-35)							—

Notes.

1. Because some of the aggregate scores measuring variables are positive and some are negative, the signs of some of the correlations were changed to accurately depict the direction of the association.

2. Number of responses varies from 2651 to 2741.

*$p < .001$.
**$p < .01$.
***$p < .05$.

CONCLUSIONS

Attitudes and Opinions

Although only 16 percent of the respondents felt that there is no real energy shortage at present, 69 percent felt that we are facing a long-term energy shortage. This indicates that many respondents felt the energy situation will become more serious than it is now. Most respondents felt that conservation can improve the situation, and they think of themselves as energy conservers. Also, most said they would put conservation before personal comfort, although this tendency was not as strong in the locations with harsh winter weather. Interestingly, respondents appeared to consider other Navy family housing residents less committed to conservation than they said they are themselves.

There appears to be considerable uncertainty and indecision concerning the causes of the present energy situation. Of the causes listed in the questionnaire, those most frequently endorsed were profiteering by oil and electrical companies and overuse of energy by commercial/industrial users. Many respondents apparently felt there is a lack of energy situation information and, further, that information we have a right to know is being withheld from us. A large majority felt well informed, however, about specific household conservation practices.

Both positive and negative economic incentives to conserve were endorsed by better than two to one margins. Somewhat fewer Great Lakes and Whiting Field residents, who were likely to be heavy users of energy because of temperature extremes in those locations, agreed that those who use too much electricity should have to pay more for it. Self-interest also appears to be reflected by the surprisingly large percentage who disagreed that people who pay for their own utilities use less energy than people who do not.

When asked to select the most important from a list of nine national topics, most respondents chose inflation and the state of the economy, with the energy situation a distant second. The energy situation was most frequently selected as the second and also as the third most important topic.

Relation Between Conservation Behaviors and Other Variables

Demographics

Age of service member, length of time in service, and pay grade seem to be positively associated with increased frequencies of reported energy conservation behaviors. These three variables are obviously highly correlated, however. Thus, it is impossible to specify whether they are all associated with conservation behaviors or if the observed effect of all three is due to the association of only one of the three or, perhaps, even a fourth, unmeasured variable.

These data do seem to rule out the effect of one potential variable in this relationship: Higher income, a direct resultant of increasing pay grade, does not appear to be an important factor. Although both the officer and enlisted groups show similar basic patterns of increasing reported energy conservation behaviors with increases in pay grade, the officers, who consistently receive higher pay than their enlisted counterparts, reported no more such behaviors than did those in the corresponding enlisted pay grades.

Location

The apparent differences in behaviors across locations indicate that, in milder climates, more respondents reported higher frequencies of energy conservation behaviors

than did those in harsher climates. Although this association may be due to the many demographic differences across locations, it also could be due to climate differences. Considerably more time and effort may be required to maintain energy conservation practices in harsher, less predictable climates than in milder climates. The amount of potential discomfort accompanying heat and cooling conservation measures is obviously greater in harsh climates. The behavior differences may reflect subjectively the degree of success that respondents have had in maintaining conservation behaviors.

Income

As previously determined by other investigators, income was associated with reported conservation behaviors: Lower economic levels seem to have higher frequencies of high conservation behavior scores. It is not, however, income in dollars that is associated with reported behaviors, but the respondents' subjective perception of their life-style or economic level. Unlike simple income level, the subjective income scale takes into account respondents' personal ratios of income to expenses. The present results indicate that, in spite of the fact that these respondents do not have to pay for their utilities, those who felt that they can least afford any extra expenses reported more conservation behaviors.

FUTURE PLANS

The present study investigated the attitudes and reported behaviors of Navy housing families concerning energy conservation. Future stages of this project will focus directly on experimental manipulations designed to promote energy conservation behavior.

In the second stage of this project, variations of three behavioral approaches will be evaluated. First, the effects of monetary incentives on the promotion of energy conservation behavior will be investigated. Second, feedback of the amount of energy consumed, but without monetary incentives, will be provided. Third, a group competition approach will be tested. This latter approach will involve periodic neighborhood group meetings, where group members will receive energy consumption feedback and discuss ideas to reduce energy use. At the end of the contest period, group members with the lowest energy consumption will share substantial monetary prizes.

During the third stage, the most promising of the above techniques will be tested and evaluated using a larger sample than that used in stage two. Also, the techniques will be tested over a sufficient period of time to test their long-term effects on household conservation behavior.

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APPENDIX A

SURVEY QUESTIONNAIRE

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA 22332

IN REPLY REFER TO

1 March 1978

Dear Family Housing Resident:

We are all aware that the world energy situation has become one of the major challenges facing us today. There is a growing realization that we can no longer assume as we have in the past that unlimited supplies of inexpensive energy will always be available to meet our needs. President Carter has recently urged all Americans to give energy conservation the highest priority.

For several years, the Naval Facilities Engineering Command has given continuing attention to saving energy in family housing units. These efforts have included installing insulation and energy saving devices such as more efficient refrigerators. The Naval Facilities Engineering Command, as the Navy's manager of Family Housing, is presently sponsoring a study being conducted by the Navy Personnel Research and Development Center, San Diego to determine the energy use attitudes, knowledge, and practices of housing residents. Much of the data gathered for this study must be obtained from residents such as you. The information provided will be used as a basis for determining the need for any future resident energy education, to identify any existing energy wasting problems with the housing units themselves, and to guide the design of future energy saving programs.

You are requested to complete the attached questionnaire and answer sheet and return them within three days in the enclosed envelope. All responses are anonymous, so please answer frankly. If you have any comments or suggestions, write them on the back of the questionnaire.

Thank you very much for your help.

Sincerely,

M. C. Mlekush

M. C. MLEKUSH
Capt., CEC, USN
Assistant Commander for
Family Housing

Enclosure:
(1) Return envelope
(2) Questionnaire

INSTRUCTIONS

- *All questions require you to respond using the special answer sheet provided.* Some questions require you to respond both by filling in the answer sheet and by writing in an answer on the questionnaire itself.

- **DO NOT** fill in your name and social security number.

- Use a pencil only. Number 2 pencil is best if it is available. Do not use pen or magic marker.

- Darken each answer block completely. If you want to change an answer, be sure to erase completely. Do not put down more than one answer to any one question.

- Important: Do not fold answer sheet

• • • • • • • •

HERE IS AN EXAMPLE OF HOW TO ENTER YOUR ANSWERS:

In what service are you now serving?

A. Air Force

B. Marine Corps

C. Navy

D. Army

SAMPLE ANSWER SHEET:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Please answer questions 1-10 about the service member in your family; if there is more than one service member answer the questions about the one **under whose name your housing is assigned.**

1. **What is the service member's sex?**
   A. Male B. Female

2. **What is the service member's status?**
   A. Officer B. Enlisted

3. **What is the highest educational level of the service member?**
   A. Elementary School
   B. Some high school
   C. High school graduate or graduate equivalent
   D. Some college
   E. Bachelor's degree
   F. Some graduate work
   G. Master's degree or equivalent
   H. Doctorate or equivalent

4. **The service member is stationed:**
   A. Ashore B. On ship C. Other

5. **The service member is now:**
   A. Living at home *(If you select this answer, skip to No. 8)*
   B. Deployed or living away from home

6. **If deployed or living away from home how long has he/she been gone?**
   A. 0 - 2 months C. 7 - 9 months E. Over 12 months
   B. 3 - 6 months D. 10 - 12 months

7. **If deployed or living away from home how long before he/she returns?**
   A. 0 - 2 months C. 7 - 9 months E. Over 12 months
   B. 3 - 6 months D. 10 - 12 months

8. **How long has the service member been in the Navy?**
   A. 2 yrs. or less D. 9 - 12 yrs. G. Over 20 yrs.
   B. 3 - 4 yrs. E. 13 - 16 yrs.
   C. 5 - 8 yrs. F. 17 - 20 yrs.

9. **What is the age of the service member?**

A. 18 - 25 yrs.	C. 31 - 40 yrs.	E. Over 50 yrs.
B. 26 - 30 yrs.	D. 41 - 50 yrs.	

10. **What is the paygrade of the service member?**

ENLISTED		OFFICER	
A. E1	F. E6	J. W1	P. 03
B. E2	G. E7	K. W2	Q. 04
C. E3	H. E8	L. W3	R. 05
D. E4	I. E9	M. W4	S. 06
E. E5		N. 01	T. 07 or over
		O. 02	

If the service member under whose name your housing is assigned is not the person filling out this questionnaire, answer questions 11 - 14 about yourself. **If this service member is filling out this questionnaire, skip to question No. 15.**

11. **What is your sex?**

A. Male B. Female

12. **How are you related to the service member?**

A. Spouse B. Child C. Other

13. **What is your age?**

A. 18 yrs. or under	C. 31 - 59 yrs.
B. 19 - 30 yrs.	D. 60 yrs. or over

14. **What is your highest educational level?**

A. Elementary school
B. Some high school
C. High school graduate or graduate equivalent degree
D. Some college
E. Bachelor's degree
F. Some graduate work
G. Master's degree or equivalent
H. Doctorate or equivalent

15. **From the responses below, select the *one* that you consider to be your racial/ethnic identity.**

A. Polynesian, Samoan, Hawaiian
B. Chinese, Japanese, Korean
C. White
D. Spanish descent (Mexican American, Puerto Rican, Cuban American, Chicano, Latino)
E. Malayan, Filipino, Guamanian
F. Black
G. Indian Tribes, Eskimo, Aleut (Native American)

16. **Which one of the statements below best describes the weather in the area where you grew up?**

A. Distinct seasons, with *cold* winters and *hot* summers.

B. Hot summers, but winters were *not* cold.

C. Cold winters, but summers were *not* very hot.

D. No distinct seasons, weather was pretty mild all year long.

17. **What is the location of your present housing?**

A. San D' go
C. Point Mugu
E. Whidbey Island
G. Other
B. Great Lakes
D. Port Hueneme
F. Whiting Field

18. **How long have you lived in your present residence?**

A. 0 - 2 months
C. 7 - 9 months
E. Over 12 months
B. 3 - 6 months
D. 10 - 12 months

19. **What type of housing do you occupy?**

A. Wherry
B. Appropriated fund built before 1950
C. Capehart or appropriated fund built between 1950 and 1969
D. Appropriated fund built 1970 or after
E. *Government Leased* housing
F. Don't know

20. **How would you describe your housing?**

A. Single house
C. Row house or townhouse
B. Semi-detached (duplex)
D. Apartment

21. **How many people live in your home? (Include yourself and all those who live with you at least 6 months a year)**

A. 1 only
D. 4
G. 7
B. 2
E. 5
H. 8
C. 3
F. 6
I. 9 or more

22. **How many of the people you counted in question No. 21 are usually at home in the evenings?**

A. None
D. 3
G. 6
B. 1 only
E. 4
H. 7
C. 2
F. 5
I. 8 or more

23. **How many of the people you counted in question No. 21 usually stay at home during the day on weekdays?**

A. None
D. 3
G. 6
B. 1 only
E. 4
H. 7
C. 2
F. 5
I. 8 or more

24. Using the scale below, select the letter of the statement which best describes your present lifestyle.

Can afford lots of luxuries	Can afford some luxuries	Comfortable; can afford everything we need	Have to budget carefully just to get by	Can't afford lots of the things we need
A	B	C	D	E

25. Using the scale below, select the letter of the statement which best describes the life style in your home when you were growing up.

Could afford lots of luxuries	Could afford some luxuries	Comfortable; could afford everything we needed	Had to budget carefully just to get by	Couldn't afford lots of the things we needed
A	B	C	D	E

26. What would you estimate your *total* family income to be? (In your estimate include all service member's cash allowances, e.g., comrats, uniform allowance.)

A. Less than $6000 yr.
B. $6,000 - $7,999 yr.
C. $ 8,000 - $9,999 yr.
D. $10,000 - $12,999 yr.
E. $13,000 - $15,999 yr.
F. $16,000 - $20,999 yr.
G. $21,000 - $24,999 yr.
H. $25,000 - $30,000 yr.
I. Over $30,000 yr.

Statements 27-35 concern various aspects of your Navy housing. Using the scale below please show how satisfied or dissatisfied you are with each one by darkening the letter of your selected answer in the appropriate space on your answer sheet.

Very Dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very Satisfied
A	B	C	D	E

27. The general appearance of the *inside* of your housing.
28. The general appearance of the *outside* of your housing.
29. The regulations concerning the remodeling of Navy housing by occupants.
30. The regulations concerning the distribution of housing.
31. The repair and maintenance service of your housing.
32. The quality of the area where your housing is located.
33. The size of your housing relative to the needs of your family.
34. Your overall rating of Navy housing.
35. The availability of Navy housing.

36. Because of the energy crisis, have you or members of your family ever experienced a shortage of natural gas or electricity to heat or light your home, school, or place of business?

A. Yes B. No *(If "No", skip to No. 38)*

37. If you answered "Yes" to No. 36, please describe the effect that the experience had on you by selecting the statement below which you find most descriptive:

A. It proved to me that my pro-conservation attitudes and practices were correct.

B. Although I always believed in energy conservation, the experience prompted me to start conserving energy.

C. Because of the experience I know that there is a real need to conserve energy and I try to conserve as much as possible.

D. Although I do not conserve as much energy as I should, the experience convinced me that there is a real need to conserve.

E. I still think there is no energy crisis, and I do not intend to change my attitudes or behaviors in any way.

38. Please select from the statements below any reason that might cause you to be using more natural gas, fuel oil, or electricity than you would under ordinary conditions. *(Select only one)*

A. No unusual conditions

B. Poor health of a family member

C. Comfort/health of an elderly member of my family

D. Comfort/health of an infant member of my family

E. Security reasons

F. Other: *(specify ______________________________).*

Using the scale below please show how much you agree or disagree with statements 39-70 by darkening the letter of your selected answer in the appropriate space on your answer sheet.

Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
A	B	C	D	E

39. If people knew more about the energy situation they would conserve more energy.

40. We should all change our way of life so that we can live with the present energy situation.

41. I would not be willing to adjust my thermostat if it made me uncomfortable in any way.

42. Occupants of military family housing conserve more energy than civilian families.

43. I think of myself as an energy conserver.

44. Foreign oil prices and restrictions are largely responsible for the present energy situation.

45. Military benefits are steadily being taken away with nothing given back to replace them.

46. The military member in my family is being fairly paid for his/her work.

Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
A	B	C	D	E

47. Regardless of the cause, we are facing a long-term energy shortage.
48. The present energy situation could be eased through energy conservation in the home.
49. In general I feel well informed about the energy situation.
50. I think I am well informed about household energy conservation practices.
51. I could conserve more energy if I knew how much I used each day.
52. Environmentalists' interference in the development of other energy sources has made the energy situation worse.
53. The Federal Government is not doing enough to find and develop new energy sources.
54. We are in the present energy situation because we are really running out of oil.
55. Depending too much on oil as an energy source has caused the present energy situation.
56. Information that we have a right to know about the energy situation is being withheld from us.
57. Profiteering by oil and electric companies is largely responsible for the present energy situation.
58. We will have sufficient energy if we develop and adopt more efficient energy saving devices.
60. My own personal comfort is more important to me than saving a little heating fuel or electricity.
61. The residents of Navy housing in my neighborhood try to conserve energy.
62. There would be enough energy if everyone quit wasting it.
63. There is no real shortage of energy.
64. Wasteful use of energy in the home is to a large extent responsible for the energy situation.
65. Rewarding people who use less energy would really promote energy conservation.
66. Those who use too much electricity should have to pay a higher rate for it.
67. People who use devices that conserve a lot of energy should get a tax break.
68. Overuse of energy by commercial/industrial users is a major cause of the present energy situation.
69. People who pay for their own utilities use less energy than people who don't.
70. Technological discoveries will provide all the energy we need long before our present sources run out.

Listed below are nine topics considered to be of national importance. In items 71 - 73 you are asked to select the three that you consider the most important.

A. The drug problem.
B. Inflation and the state of the economy.
C. Middle East situation.
D. Crime.
E. The energy situation.
F. Unemployment.
G. Racial equality.
H. Women's rights.
I. Mass transportation.

71. Which is the FIRST most important?

72. Which is the SECOND most important?

73. Which is the THIRD most important?

Statements 74 - 87 below are about actions concerning energy conservation. Darken on your answer sheet "A" for those that you have done; "B" for those that you have not done; and "C" for those that are not applicable.

74. Instructed family members about energy conservation.

75. Talked with friends about the energy situation.

76. Tried to learn more about energy conservation practices.

77. Signed a petition promoting energy conservation.

78. Set air conditioning thermostat no lower than 78 degrees F.

79. Participated in a group which promotes energy conservation.

80. Set refrigerator thermostat to a warmer setting.

81. Attended any discussions about the energy situation.

82. Replaced light bulbs with ones of lower wattage.

83. Written to a government official about the government's efforts at energy conservation.

84. Supported legislation designed to save energy.

85. Written to a newspaper or other publication concerning some aspect of the energy situation.

86. Set your water heater thermostat to a medium or low setting.

87. Supported a political candidate because of his/her strong stand in favor of energy conservation.

Using the scale below please show how often statements 88 - 119 are done in your home by darkening the letter of your response in the appropriate space on your answer sheet.

All the time	Most of the time	Often	Once in a while	Never	Does not apply
A	B	C	D	E	F

88. Wash only full loads of laundry.
89. Have lights on with no one in the room.
90. Keep your heater thermostat no higher than 68 degrees F.
91. Have outside window or door open while heating or air conditioning is on.
92. Use only one T.V. at a time (If you have none or only one, darken space "F" on the answer sheet).
93. Use the dishwasher when it is only partially full.
94. Use oven or broiler to heat small items such as sandwiches.
95. Turn off heating vents in rooms not being used.
96. Turn heating down or off when no one is home.
97. Have T.V. on with no one in the room.
98. Have more than one T.V. on at the same time, both tuned to the same program.
99. Remind family members to conserve energy.
100. Shower or bathe in cooler water than you used to.
101. Take short showers (5 minutes or less).
102. Leave oven on after food has been taken out.
103. Wash hair while in the shower.
104. Leave draperies/curtains open during the day when air conditioning is on.
105. Plan ahead to get all needed items out of refrigerator at one time.
106. Use clothes washer when it is partially full.
107. Turn down heater thermostat before going to bed at night.
108. Keep outside windows and doors closed as much as possible when household heating or air conditioning is on.
109. Pre-heat your oven for foods such as roasts, casseroles, etc.
110. Run hot water to wash dishes instead of filling the sink with water.
111. Take showers instead of baths.
112. Leave electric blanket on after getting up.
113. Turn your oven on to heat your kitchen.
114. Reduce the number of lights burning at the same time.
115. Use clothes dryer with less than full loads.
116. Use cooking timer, rather than frequently opening the oven door to determine when food is ready to be taken out of the oven.
117. Adjust stove burner flame so that it fits the size of the pot or pan you are cooking with.
118. Leave refrigerator door open while doing other things (snacking, putting other non refrigerated groceries away, etc.).
119. Wash clothes in cold water.

For statements 120 - 130, darken on your answer sheet "A" for those that you would be willing to do; "B" for those that you would *NOT* be willing to do.

120. Read informational literature about the energy situation.
121. Support a political candidate for his/her strong support of energy conservation.
122. Instruct and remind your family about energy conservation.
123. Participate in an experiment in which you would receive money or gifts for conserving energy.
124. Support energy conservation legislation even though it might raise your taxes slightly.
125. Shut off your household heating except on cold days (below 65 degrees F).
126. Shut off your water heater.
127. Replace light bulbs with bulbs of lower wattage.
128. Be part of an experiment in which the names of energy overusers are printed in the local newspaper.
129. Wash clothes in cold water most of the time.
130. Turn down heater thermostat to 65 degrees F.

Statements 131 - 139 are about problems your housing may have which would waste energy. Darken on your answer sheet "A" for those that you have noticed in your home; "B" for those that you have not seen in your home. No. 139 is included for you to list any other energy wasting problems that you have noticed in your housing. If you do write in an answer below, be sure also to fill in "A" on the answer sheet.

131. Doors that do not close tightly.
132. Windows that do not close tightly.
133. Cracks in floors, walls, ceilings, etc.
134. Refrigerator which does not have tight door seal.
135. Hot water faucets that drip.
136. Drapes or curtains missing.
137. Cracked or broken windows.
138. Rooms (other than kitchen or bathroom) without carpeting.
139. Other *(Specify: ______________________________________).*

For statements 140 - 151 darken an "A" on your answer sheet for those statements that you think are *true* and a "B" for those statements that you think are *false.*

140. It takes energy in some form to generate electricity.
141. Electricity can be economically stored in large amounts for use when we need it.
142. Most of our natural gas is produced artificially.
143. Fluorescent light bulbs can use *less* energy and yet produce *more* light than incandescent bulbs.
144. The United States has 40% of the world's oil reserves.

145. A nearly full freezer generally uses *less* energy than ones that are not so full.

146. The same natural process which results in oil and coal also produces natural gas.

147. A 150 watt light bulb produces *twice* the light of a 75 watt bulb but uses *three* times more electricity.

148. The United States imports *more* than 25% of its oil.

149. Putting extra soap in with your clothes wash can *increase* the amount of electricity that the machine uses.

150. The amount of frost in your freezer does *not* affect the amount of energy it uses.

151. When we generate electricity, we produce *more* energy than we expend to run the generators.

152. At what setting do you keep your heating thermostat when the house is occupied during the day?

A. 65° F or less	D. 68° F	G. 71° F
B. 66° F	E. 69° F	H. 72° F
C. 67° F	F. 70° F	I. 73° F or more

153. At what setting do you keep your heating thermostat after you go to bed at night?

A. 65° F or less	D. 68° F	G. 71° F
B. 66° F	E. 69° F	H. 72° F
C. 67° F	F. 70° F	I. 73° F or more

154. At what setting do you keep your cooling system on when it is being used during the day?

A. We have no cooling system	D. 72° F	G. 78° F
B. 68° F or less	E. 74° F	H. 80° F
C. 70° F	F. 76° F	I. 82° F or more

155. At what setting do you keep your cooling system after you go to bed at night?

A. We have no cooling system	D. 72° F	G. 78° F
B. 68° F or less	E. 74° F	H. 80° F
C. 70° F	F. 76° F	I. 82° F or more

156. Do you own a TV that has an instant "on" feature?

A. No

B. Yes, just one

C. Yes, more than one

Thank you!

APPENDIX B

RESPONSE PERCENTAGE DISTRIBUTION BY LOCATION

Table B-1

Response Percentage Distribution by Location

Item	Location: San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
1. Service member's sex	(957)	(804)	(232)	(188)	(311)	(191)	(2683)
Male	99.0%	97.5%	97.4%	98.4%	99.4%	99.5%	98.4%
Female	1.0	2.5	2.6	1.6	.6	.5	1.6
2. Service member's status	(956)	(802)	(232)	(188)	(312)	(191)	(2681)
Officer	13.2	13.6	17.7	26.1	23.1	40.8	17.7
Enlisted	86.8	86.4	82.3	73.9	76.9	59.2	82.3
3. Highest educational level of service member	(953)	(803)	(231)	(187)	(311)	(191)	(2676)
Elementary school	.3	.2	0	.5	.3	0	.3
Some high school	3.3	3.4	4.3	4.3	3.5	4.2	3.6
H.S. graduate or equivalent	44.7	45.2	45.5	46.0	35.4	33.5	43.1
Some college	39.0	35.9	33.3	23.0	37.0	24.1	35.2
Bachelor's degree	5.7	7.3	6.9	7.0	16.7	34.0	9.7
Some graduate work	2.7	2.2	3.0	2.7	3.5	3.7	2.8
Master's degree	3.7	3.1	6.1	13.9	3.2	.5	4.1
Doctorate	.6	2.6	.9	2.7	.3	0	1.3
4. Service member's station	(885)	(792)	(190)	(115)	(266)	(190)	(2438)
Ashore	51.6	98.7	97.9	87.8	82.0	99.5	79.6
On ship	48.4	.3	2.1	12.2	18.0	.5	20.4

Note: Number responding to each item is shown in parentheses.

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
5. The service member is now:	(942)	(798)	(232)	(188)	(306)	(189)	(2655)
Living at home	79.1%	98.9%	90.5%	69.1%	81.0%	96.8%	86.8%
Deployed or living away from home	20.9	1.1	9.5	30.9	19.0	3.2	13.2
If Service member is deployed or living away from home:							
6. How long has he/she been gone?	(54)	(42)	(17)	(7)	(16)	(11)	(147)
0-2 mos.	27.8	47.6	64.7	28.6	37.5	36.4	39.5
3-6 mos.	13.0	2.4	5.9	28.6	6.3	9.1	8.8
7-9 mos.	24.1	16.7	17.6	42.9	37.5	18.2	23.1
10-12 mos.	22.2	19.0	11.8	0	0	27.3	17.0
Over 12 mos.	13.0	14.3	0	0	18.8	9.1	11.6
7. How long before he/she returns?	(33)	(27)	(13)	(6)	(8)	(6)	(93)
0-2 mos.	60.6	66.7	76.9	33.3	100.0	50.0	65.6
3-6 mos.	12.1	18.5	0	16.7	0	16.7	11.8
7-9 mos.	18.2	14.8	15.4	50.0	0	16.7	17.2
10-12 mos.	3.0	0	0	0	0	0	1.1
Over 12 mos.	6.1	0	7.7	0	0	16.7	4.3
8. How long has service member been in the Navy?	(940)	(785)	(225)	(184)	(308)	(187)	(2629)
2 yrs. or less	1.0	5.9	.4	4.3	8.4	21.9	5.0
3-4 yrs.	5.2	5.0	1.8	6.5	10.1	15.0	6.2
5-8 yrs.	19.3	21.3	20.9	17.4	26.9	27.8	21.4
9-12 yrs.	21.5	21.7	28.4	21.2	18.8	14.4	21.3
13-16 yrs.	24.9	20.0	23.1	26.1	14.9	7.0	20.9
17-20 yrs.	18.2	18.5	16.9	14.1	13.3	10.7	16.8
Over 20 yrs.	10.0	7.8	8.4	10.3	7.5	3.2	8.4

Item	San Diego		Great Lakes		Pt. Mugu		Port Hueneme		Whidbey Is.		Whiting Field		Total	
	Location													
9. What is age of service member?	(953)		(803)		(231)		(188)		(311)		(190)		(2676)	
18-25 yrs	9.9%		13.9%		9.1%		9.6%		22.5%		35.3%		14.3%	
26-30 yrs	27.4		29.6		30.7		25.5		31.5		37.9		29.4	
31-40 yrs	53.2		48.8		50.6		43.6		39.9		23.2		47.3	
41-50 yrs	9.2		7.5		9.1		19.7		5.8		3.2		8.6	
Over 50 yrs	.3		.1		.4		1.6		.3		.5		.4	
10. What is paygrade of service member?	(944)		(796)		(231)		(185)		(310)		(188)		(2654)	
	% All	% Enl	% All	% Enl	% All	% Enl	% All	% Enl	% All	% Enl	% All	% Enl	% All	% Enl
E1	0	0	0	0	0	0	0	0	0	0	.5	.9	0	0
E2	.1	.1	.2	.3	0	0	0	0	.6	.8	.5	.9	.2	.3
E3	.3	.4	1.6	1.9	.4	.5	0	0	2.9	3.8	1.6	2.6	1.1	1.3
E4	3.8	4.4	6.8	7.7	3.0	3.6	5.4	7.2	6.4	8.4	9.6	15.8	5.5	6.6
E5	21.3	24.5	13.8	15.8	26.4	31.8	28.1	37.7	22.6	29.3	20.2	33.3	20.0	24.2
E6	36.3	41.7	30.8	35.2	36.8	44.3	20.5	27.5	28.4	36.8	19.7	32.5	31.5	38.0
E7	19.6	22.5	24.4	27.9	13.4	16.1	16.2	21.7	11.6	15.1	6.4	10.5	18.4	22.2
E8	4.6	5.2	6.6	7.6	3.0	3.6	2.7	3.6	3.5	4.6	2.1	3.5	4.6	5.6
E9	1.0	1.2	3.1	3.6	0	0	1.6	2.2	1.0	1.2	0	0	1.5	1.9
	-	100%	-	100%	-	100%	-	100%	-	100%	-	100%	-	100%
		% Off		% Off		% Off		% Off		% Off		% Off		% Off
W1	0	0	.1	1.0	0	0	0	0	.3	1.4	0	0	.1	.4
W2	.8	6.6	.9	7.0	0	0	1.1	4.3	.6	2.8	.5	1.4	.8	4.4
W3	.5	4.1	0	0	.4	2.6	.5	2.1	.3	1.4	0	0	.3	1.8
W4	.4	3.3	.1	1.0	.4	2.6	.5	2.1	0	0	0	0	.3	1.5
01	1.2	9.0	1.4	11.0	0	0	.5	2.1	2.2	9.9	21.3	54.0	2.6	15.5
02	2.3	18.0	1.5	12.0	.9	5.1	3.2	12.8	6.1	26.8	8.0	20.3	2.9	16.8
03	2.8	21.3	3.9	31.0	3.9	23.1	7.0	27.7	8.4	36.6	6.9	17.6	4.4	26.0
04	2.2	17.2	2.5	20.0	6.9	41.0	6.5	25.5	2.9	12.7	1.6	4.0	3.0	17.9
05	1.0	8.2	2.0	16.0	2.6	15.4	2.7	10.6	1.6	7.0	.5	1.4	1.6	9.5
06	1.5	11.5	.1	1.0	1.7	10.2	3.2	12.8	.3	1.4	.5	1.4	1.0	6.0
07	.1	.8	0	0	0	0	0	0	0	0	0	0	0	.2
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
If someone other than service member is completing the questionnaire:							
11. What is your sex?	(531)	(341)	(110)	(107)	(152)	(84)	(1325)
Male	4.1%	9.7%	6.4%	6.5%	4.6%	4.8%	6.0%
Female	95.9	90.3	93.6	93.5	95.4	95.2	94.0
12. How are you related to service member?	(521)	(321)	(107)	(103)	(146)	(81)	(1279)
Spouse	98.7	99.1	100.0	98.1	100.0	98.8	99.0
Child	.8	.6	0	1.0	0	0	.5
Other	.6	.3	0	1.0	0	1.2	.5
13. What is your age?	(518)	(322)	(107)	(102)	(144)	(81)	(1274)
18 yrs. or under	0	.9	0	0	1.4	0	.4
19-30 yrs.	52.3	62.1	57.9	46.1	66.0	90.1	58.7
31-59 yrs.	47.5	36.6	42.1	53.9	32.6	9.9	40.7
60 yrs. or over	.2	.3	0	0	0	0	.2
14. What is your highest education level?	(518)	(319)	(106)	(103)	(145)	(81)	(1272)
Elementary school	1.0	.3	.9	0	.7	0	.6
Some high school	11.2	9.7	5.7	11.7	11.0	6.2	10.1
High school graduate	41.5	44.2	47.2	38.8	37.9	33.3	41.5
Some college	38.2	36.1	40.6	32.0	35.2	42.0	37.3
Bachelor's degree	5.2	6.9	1.9	15.5	11.0	16.0	7.5
Some graduate work	1.9	.9	3.8	0	3.4	2.5	1.9
Master's degree	1.0	1.9	0	1.9	.7	0	1.1
Doctorate	0	0	0	0	0	0	0

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
15. What is your racial/ ethnic identity?	(934)	(789)	(224)	(184)	(305)	(188)	(2624)
Polynesian, Samoan, or Hawaiian	.4%	.1%	.4%	.5%	.7%	0%	.3%
Chinese, Japanese, or Korean	.5	.4	0	0	.7	0	.4
White	83.9	91.4	89.7	82.1	90.8	89.9	87.8
Spanish Descent	5.4	1.6	4.0	1.6	2.3	2.1	3.3
Malayan, Filipino, or Guamanian	3.9	3.7	3.6	10.9	2.0	3.7	4.0
Black	4.2	1.6	.9	1.6	2.0	3.2	2.6
Indian Tribes, Eskimo or Aleut	1.7	1.1	1.3	3.3	1.6	1.1	1.6
16. What was the weather like where you grew up?	(957)	(806)	(233)	(187)	(313)	(190)	(2686)
Distinct seasons, cold winters-hot summers	61.1	69.2	52.8	59.9	55.9	65.8	62.5
Hot summers but winters not cold	13.5	11.0	15.0	13.9	13.1	18.4	13.2
Cold winters but summers not very hot	7.9	12.0	7.7	6.4	20.4	7.4	10.5
No distinct seasons, weather mild all year long	17.5	7.7	24.5	19.8	10.5	8.4	13.8
17. What is the location of your present housing?							

Item	Location: San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
18. How long have you lived at your present residence?	(956)	(804)	(233)	(188)	(314)	(190)	(2685)
0-2 mos.	8.2%	6.7%	6.9%	8.0%	5.1%	9.5%	7.3%
3-6 mos.	14.5	11.9	16.3	22.9	14.3	20.0	14.9
7-9 mos.	12.8	15.4	17.6	13.8	15.3	20.5	14.9
10-12 mos.	9.0	10.9	6.9	6.9	6.4	14.7	9.3
Over 12 mos.	55.5	55.0	52.4	48.4	58.9	35.3	53.6
19. What type of housing do you occupy?	(644)	(549)	(183)	(93)	(257)	(185)	(1911)
Wherry	4.3	10.4	.5	4.3	.4	13.5	6.1
App. fund, built before 1950	14.8	15.8	6.0	21.5	12.5	1.1	12.9
Capehart or app. fund built 1950-1969	28.0	51.0	91.3	65.6	77.4	84.9	54.6
Appropriated, built 1970 or after	44.6	19.9	.5	4.3	8.2	.5	22.1
Government leased housing	8.4	2.9	1.6	4.3	1.6	0	4.2
20. How would you describe your housing?	(954)	(803)	(231)	(186)	(313)	(191)	(2678)
Single house	27.5	7.7	55.0	17.7	63.3	50.8	29.1
Semi-detached (duplex)	32.4	26.9	25.1	42.5	8.6	41.4	28.7
Row house or townhouse	22.7	41.7	16.0	21.0	17.6	3.7	25.8
Apartment	17.4	23.7	3.9	18.8	10.5	4.2	16.5

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
21. How many people live in your home?	(958)	(804)	(233)	(188)	(314)	(191)	(2688)
1 only	0	0	0	1.1	0	0	.1
2	3.9	9.3	6.9	9.0	13.1	18.3	8.2
3	14.1	22.5	16.7	21.3	21.7	26.7	19.1
4	40.8	37.9	48.5	35.1	40.8	37.7	40.0
5	24.3	21.4	18.9	19.1	17.5	14.1	21.1
6	13.6	6.3	6.0	10.1	5.4	2.1	8.7
7	2.1	1.9	2.1	2.7	1.0	0	1.8
8	.7	.5	.9	1.1	.3	.5	.6
9 or more	.5	.1	0	.5	.3	.5	.3
Mean Number:	4.4	4.0	4.1	4.1	3.9	3.6	4.1
22. How many people counted in #21 living in your home are home evenings?	(955)	(806)	(233)	(188)	(314)	(191)	(2687)
0	.1	.1	.4	.5	.6	.5	.3
1	1.0	1.7	1.7	3.2	.6	3.7	1.6
2	7.0	12.3	10.7	15.4	15.6	17.8	11.3
3	23.0	26.8	23.6	23.4	29.0	30.9	25.5
4	37.0	34.1	39.1	29.3	32.5	32.5	34.9
5	19.9	17.5	15.9	16.5	15.6	12.0	17.5
6	9.3	5.7	6.4	8.0	4.8	1.6	6.8
7	1.4	1.1	1.7	2.7	.6	0	1.2
8 or more	1.3	.6	.4	1.1	.6	1.0	.9
Mean number:	4.1	3.8	3.8	3.8	3.6	3.4	3.8

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
23. How many people counted in #21 living in your home are home week-days?	(953)	(806)	(233)	(188)	(314)	(191)	(2685)
0	16.5%	20.0%	14.2%	20.2%	11.8%	17.8%	17.1%
1	20.8	17.1	23.6	24.5	23.6	19.9	20.4
2	23.5	26.8	27.9	26.1	29.0	30.4	26.2
3	21.3	20.8	18.5	19.7	18.8	18.8	20.3
4	12.2	9.4	10.3	5.9	11.8	10.5	10.6
5	3.5	3.7	4.3	2.1	4.5	2.1	3.5
6	1.8	1.4	.9	1.1	.6	0	1.3
7	.2	.5	.4	.5	0	0	.3
8 or more	.3	.2	0	0	0	.5	.2
Mean number:	2.1	2.0	2.1	1.8	2.1	1.9	2.1
24. What is your present life-style?	(95[illegible])	(801)	(233)	(187)	(313)	(188)	(2676)
Score: 0. Can afford lots of luxuries	.1	.5	1.3	.5	.3	0	.4
1. Can afford some luxuries	10.4	15.1	13.3	15.0	17.6	18.6	13.8
2. Can afford all we need	35.2	41.1	39.5	38.0	39.9	49.5	39.1
3. Have to budget carefully to get by	45.0	38.7	39.9	38.5	35.1	28.2	39.9
4. Can't afford lots of things we need	9.3	4.6	6.0	8.0	7.0	3.7	6.9
Mean Score:	2.53	2.32	2.36	2.39	2.31	2.17	2.39

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
25. What was your life-style when you were growing up?	(956)	(803)	(233)	(188)	(312)	(189)	(2681)
Score: 0. Could afford lots of luxuries	2.0%	1.5%	1.3%	1.1%	2.2%	3.7%	1.9%
1. Could afford some luxuries	16.6	16.7	13.3	10.6	18.9	22.2	16.6
2. Could afford all we needed	32.8	33.7	39.9	31.9	34.0	34.4	33.9
3. Had to budget carefully just to get by	28.8	31.3	29.6	33.5	29.2	25.4	29.7
4. Couldn't afford lots of the things we needed	19.8	16.8	15.9	22.9	15.7	14.3	17.9
Mean Score:	2.48	2.45	2.45	2.66	2.37	2.24	2.45
26. What is your total family income?	(946)	(797)	(229)	(184)	(308)	(189)	(2653)
Score: 0. Less than $6000/yr	1.1	2.1	.9	.5	[illegible].2	2.6	1.8
1. $6000 to $7999/yr	11.0	8.5	10.5	13.6	13.0	12.7	10.7
2. $8000 to $9999/yr	24.5	19.7	24.0	22.3	21.4	21.2	22.3
3. $10000 to $12999/yr	32.8	32.5	28.8	17.9	26.9	29.1	30.4
4. $13000 to $15999/yr	14.2	17.4	12.7	17.4	14.3	18.0	15.5
5. $16000 to $20999/yr	9.1	11.4	10.5	13.6	11.0	9.0	10.4
6. $21000 to $24999/yr	4.2	4.0	6.1	6.5	4.9	5.8	4.7
7. $25000 to $30000/yr	1.9	2.8	3.1	4.9	3.6	1.1	2.6
8. Over $30000/yr	1.3	1.5	3.5	3.3	.6	.5	1.5
Mean Score:	3.09	3.28	3.34	3.49	3.08	3.06	3.19

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
How satisfied or dissatisfied are you with:							
27. General appearance of the inside of your housing?	(959)	(805)	(232)	(187)	(314)	(191)	(2688)
Very dissatisfied	1.9%	5.2%	1.7%	4.3%	1.0%	1.0%	2.9%
Dissatisfied	9.2	16.1	9.5	9.1	5.1	6.8	10.6
Neither satisfied nor dissatisfied	14.1	21.0	14.7	20.9	15.6	17.3	17.1
Satisfied	55.1	48.3	60.8	51.9	61.5	63.4	54.7
Very satisfied	19.8	9.3	13.4	13.9	16.9	11.5	14.8
28. The general appearance of the outside of your housing?	(957)	(806)	(232)	(187)	(314)	(191)	(2687)
Very dissatisfied	5.0	15.8	5.2	2.1	6.7	1.6	8.0
Dissatisfied	16.5	22.1	15.5	21.4	23.6	12.6	19.0
Neither satisfied nor dissatisfied	18.8	18.9	20.7	17.6	19.7	18.8	19.0
Satisfied	47.4	38.2	51.3	43.9	41.4	57.6	44.8
Very satisfied	12.2	5.1	7.3	15.0	8.6	9.4	9.2
29. The regulations concerning the remodeling of Navy housing by occupants?	(952)	(805)	(230)	(182)	(314)	(191)	(2674)
Very dissatisfied	6.9	14.8	5.7	7.7	6.1	4.7	9.0
Dissatisfied	23.9	28.4	19.6	17.0	18.8	12.0	23.0
Neither satisfied nor dissatisfied	35.8	31.9	39.6	37.4	40.1	41.9	36.0
Satisfied	29.5	23.4	32.6	34.1	32.2	39.8	29.3
Very satisfied	3.8	1.5	2.6	3.8	2.9	1.6	2.7

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
How satisfied or dissatisfied are you with:							
30. The regulations concerning the distribution of housing?	(951)	(803)	(231)	(182)	(313)	(191)	(2671)
Very dissatisfied	13.5%	18.6%	16.5%	13.7%	6.7%	6.3%	14.0%
Dissatisfied	20.8	22.5	19.5	20.3	16.9	18.8	20.6
Neither satisfied nor dissatisfied	27.2	26.4	26.0	25.8	27.2	26.7	26.7
Satisfied	36.3	29.9	34.6	33.5	43.8	45.0	35.5
Very satisfied	2.2	2.6	3.5	6.6	5.4	3.1	3.2
31. The repair and maintenance service of your housing?	(956)	(804)	(231)	(186)	(314)	(191)	(2682)
Very dissatisfied	6.1	8.3	10.8	6.5	3.2	3.1	6.6
Dissatisfied	16.2	14.9	18.6	15.6	10.8	12.0	15.1
Neither satisfied nor dissatisfied	16.9	16.8	15.2	11.3	13.4	12.0	15.6
Satisfied	47.4	47.6	43.7	48.9	51.3	52.9	48.1
Very satisfied	13.4	12.3	11.7	17.7	21.3	19.9	14.6
32. The quality of the area where your housing is located?	(957)	(805)	(231)	(188)	(313)	(191)	(2685)
Very dissatisfied	3.6	7.8	2.6	4.8	3.2	1.6	4.7
Dissatisfied	7.9	13.4	5.2	5.9	5.8	8.9	9.0
Neither satisfied nor dissatisfied	14.6	22.5	13.4	13.3	8.9	12.0	15.9
Satisfied	48.4	48.1	54.5	57.4	49.5	53.9	50.0
Very satisfied	25.5	8.2	24.2	18.6	32.6	23.6	20.4

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
How satisfied or dissatisfied are you with:							
33. The size of your housing relative to the needs of your family?	(957)	(806)	(231)	(187)	(314)	(191)	(2686)
Very dissatisfied	5.3%	9.1%	4.3%	7.5%	5.4%	1.6%	6.3%
Dissatisfied	12.6	14.9	10.8	13.4	10.5	12.0	12.9
Neither satisfied nor dissatisfied	8.6	8.4	9.5	5.9	6.1	5.8	7.9
Satisfied	47.1	45.8	41.6	45.5	49.4	49.2	46.5
Very satisfied	26.3	21.8	33.8	27.8	28.7	31.4	26.4
34. Your overall rating of Navy housing?	(953)	(805)	(232)	(185)	(314)	(191)	(2680)
Very dissatisfied	2.7	7.5	3.0	3.8	2.5	.5	4.1
Dissatisfied	12.2	18.8	6.9	9.7	13.4	8.9	13.4
Neither satisfied nor dissatisfied	20.8	25.7	19.8	26.5	19.1	15.7	22.0
Satisfied	53.6	43.9	59.9	49.2	53.8	65.4	51.8
Very satisfied	10.7	4.2	10.3	10.8	11.1	9.4	8.7
35. The availability of Navy housing?	(957)	(805)	(231)	(186)	(314)	(190)	(2683)
Very dissatisfied	42.9	19.1	24.2	20.4	11.8	13.7	26.9
Dissatisfied	33.3	34.9	33.8	29.6	26.1	30.0	32.5
Neither satisfied nor dissatisfied	11.0	19.4	18.6	20.4	18.8	17.4	16.2
Satisfied	11.7	23.9	20.3	25.3	38.2	36.3	21.9
Very satisfied	1.0	2.7	3.0	4.3	5.1	2.6	2.5

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
36. Have you experienced a natural gas or electricity shortage?	(938)	(798)	(227)	(182)	(310)	(189)	(2644)
(% "Yes")	12.0%	13.8%	15.9%	13.2%	14.5%	17.5%	13.7%
37. If answered "Yes" to #36, what effect did experience have on you?	(110)	(105)	(37)	(23)	(45)	(32)	(352)
A. Proved my pro-conservation attitudes and practices correct.	19.1	21.0	24.3	17.4	20.0	37.5	21.9
B. Always believed in conservation, but experience prompted me to start conserving.	11.8	14.3	18.9	13.0	17.8	6.3	13.6
C. Know there is a real need because of experience and try to conserve as much as possible.	49.1	34.3	35.1	39.1	46.7	34.4	40.9
D. Don't conserve as much as I should, but experience convinced me of need to conserve.	16.4	22.9	21.6	17.4	13.3	18.8	18.8
E. Still think there's no energy crisis and do not intend to change attitudes or behaviors in any way.	3.6	7.6	0	13.0	2.2	3.1	4.8

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
38. Reason that might cause more natural gas, fuel oil, or electricity use than under ordinary conditions:	(910)	(768)	(222)	(169)	(300)	(186)	(2555)
No unusual conditions	52.4%	44.9%	56.8%	58.0%	52.7%	52.2%	50.9%
Family member's poor health	11.3	6.9	7.2	10.1	8.3	8.6	9.0
Elderly family member	.7	.5	1.4	.6	1.3	1.1	.8
Infant family member	15.5	21.6	18.0	16.0	22.0	29.6	19.4
Security reasons	14.5	5.3	10.4	10.7	2.7	1.1	8.8
Other	5.6	20.7	6.3	4.7	13.0	7.5	11.2
39. If people knew more about the energy situation they would conserve more.	(956)	(803)	(233)	(188)	(313)	(191)	(2684)
Strongly agree	12.0	8.8	13.3	14.4	8.0	12.6	10.9
Agree	40.3	39.0	38.6	39.4	47.6	41.4	40.6
Neither agree nor disagree	22.5	23.5	21.0	21.3	18.8	23.0	22.2
Disagree	22.9	26.3	25.8	22.9	24.6	20.4	24.2
Strongly disagree	2.3	2.4	1.3	2.1	1.0	2.6	2.1
40. We should all change our way of life so that we can live with the present energy situation.	(956)	(806)	(233)	(188)	(312)	(191)	(2686)
Strongly Agree	13.1	12.2	16.3	16.5	15.1	13.6	13.6
Agree	48.4	46.0	42.5	38.8	52.2	45.5	46.8
Neither agree nor disagree	24.0	23.6	22.3	26.6	18.9	23.0	23.2
Disagree	13.0	15.5	14.6	14.4	11.9	17.3	14.1
Strongly disagree	1.6	2.7	[illegible].3	3.7	1.9	.5	[illegible]

Item	Location: San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
41. I would not be willing to adjust my thermostat if it made me uncomfortable in any way.	(955)	(804)	(233)	(188)	(313)	(190)	(2683)
Strongly agree	2.3%	4.1%	3.4%	1.1%	2.6%	4.2%	3.0%
Agree	11.9	17.8	10.3	12.8	11.5	10.5	13.5
Neither agree nor disagree	18.2	18.9	17.2	18.1	21.4	18.9	18.7
Disagree	55.5	50.5	56.7	57.4	51.8	56.3	53.9
Strongly disagree	12.0	8.7	12.4	10.6	12.8	10.0	10.9
42. Occupants of military family housing conserve more energy than civilian families.	(958)	(806)	(233)	(187)	(313)	(191)	(2688)
Strongly agree	3.3	3.6	4.7	7.5	1.0	1.6	3.4
Agree	10.3	9.1	13.3	9.1	9.3	5.8	9.7
Neither agree nor disagree	38.7	39.5	46.4	35.3	37.4	40.8	39.4
Disagree	33.0	30.6	23.6	32.1	34.5	39.3	32.0
Strongly disagree	14.6	17.2	12.0	16.0	17.9	12.6	15.5
43. I think of myself as an energy conserver.	(959)	(805)	(233)	(187)	(314)	(191)	(2689)
Strongly agree	16.6	12.2	12.9	19.3	14.6	10.5	14.5
Agree	60.5	55.2	56.2	53.5	58.9	56.5	57.6
Neither agree nor disagree	19.3	27.7	26.6	22.5	22.3	27.2	23.6
Disagree	3.0	4.5	3.4	4.3	3.8	5.2	3.8
Strongly disagree	.6	.5	.9	.5	.3	.5	.6

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
44. Foreign oil prices and restrictions are largely responsible for the present energy situation.	(955)	(804)	(232)	(187)	(313)	(191)	(2682)
Strongly agree	14.3%	16.3%	15.1%	14.4%	12.1%	13.1%	14.7%
Agree	28.6	26.0	22.4	28.3	23.0	26.2	26.4
Neither agree nor disagree	25.9	25.6	28.0	26.7	27.2	20.4	25.8
Disagree	23.9	22.8	24.6	23.0	31.0	30.4	24.8
Strongly disagree	7.3	9.3	9.9	7.5	6.7	9.9	8.3
45. Military benefits are being taken away with nothing given back to replace them.	(955)	(806)	(233)	(185)	(313)	(189)	(2681)
Strongly agree	69.0	65.6	65.2	62.2	57.8	59.8	65.2
Agree	22.9	25.4	27.5	24.3	31.9	27.5	25.6
Neither agree nor disagree	4.9	5.7	3.4	8.6	8.0	11.1	6.1
Disagree	1.9	2.2	2.1	2.2	1.3	1.1	1.9
Strongly disagree	1.3	1.0	1.7	2.7	1.0	.5	1.2
46. The military member in my family is being paid fairly for his/her work.	(953)	(801)	(232)	(187)	(313)	(190)	(2676)
Strongly agree	3.5	2.7	1.7	3.2	2.2	5.8	3.1
Agree	15.9	19.2	27.6	27.8	25.9	33.7	21.2
Neither agree nor disagree	12.7	13.1	10.3	20.3	15.0	17.9	13.8
Disagree	30.6	33.5	27.6	30.5	33.5	26.8	31.3
Strongly disagree	37.3	31.5	32.8	18.2	23.3	15.8	30.6

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
47. Regardless of the cause, we are facing a long-term energy shortage.	(958)	(805)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	16.9%	15.2%	20.6%	17.0%	18.2%	15.7%	16.8%
Agree	54.2	51.3	48.5	52.1	52.9	51.8	52.4
Neither agree nor disagree	20.1	21.0	20.6	21.8	20.7	18.3	20.5
Disagree	7.5	10.9	9.9	6.9	7.3	11.5	9.0
Strongly disagree	1.3	1.6	.4	2.1	1.0	2.6	1.4
48. The present energy situation could be eased through conservation in the home.	(958)	(806)	(233)	(187)	(314)	(191)	(2689)
Strongly agree	10.0	8.4	9.9	10.7	12.1	13.6	10.1
Agree	52.1	52.2	55.4	53.5	54.8	56.5	53.1
Neither agree nor disagree	23.8	23.8	21.0	19.3	19.1	18.8	22.4
Disagree	12.3	13.8	11.6	15.0	12.4	9.4	12.7
Strongly disagree	1.8	1.7	2.1	1.6	1.6	1.6	1.7
49. In general I feel well informed about the energy situation.	(957)	(806)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	5.5	7.2	7.7	8.0	5.7	2.6	6.2
Agree	40.2	38.5	43.8	38.8	42.0	37.2	39.9
Neither agree nor disagree	24.8	26.4	25.8	21.8	22.3	25.1	24.9
Disagree	23.4	23.1	18.9	24.5	25.5	28.8	23.6
Strongly disagree	6.1	4.8	3.9	6.9	4.5	6.3	5.4

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
50. I think I am well informed about household energy conservation practices.	(959)	(806)	(233)	(188)	(314)	(191)	(2691)
Strongly agree	10.9%	12.8%	13.3%	13.3%	10.8%	9.4%	11.7%
Agree	68.3	67.5	68.7	68.6	67.5	64.9	67.8
Neither agree nor disagree	11.9	12.5	10.7	9.0	12.1	16.8	12.2
Disagree	7.5	6.2	6.4	8.5	8.3	7.3	7.2
Strongly disagree	1.4	1.0	.9	.5	1.3	1.6	1.2
51. I could conserve more energy if I knew how much I used each day.	(959)	(806)	(232)	(188)	(314)	(191)	(2690)
Strongly agree	5.1	4.1	7.8	7.4	11.5	7.9	6.1
Agree	34.3	32.5	31.9	29.3	35.7	41.9	33.9
Neither agree nor disagree	29.2	27.8	29.3	32.4	24.5	24.6	28.1
Disagree	26.4	30.9	27.2	25.5	26.4	24.6	27.6
Strongly disagree	5.0	4.7	3.9	5.3	1.9	1.0	4.2
52. Environmentalists' interference in development of other energy sources has made the energy situation worse.	(956)	(806)	(233)	(188)	(313)	(191)	(2687)
Strongly agree	17.6	16.5	15.5	16.0	16.9	15.7	16.7
Agree	29.5	26.4	30.0	27.1	28.4	23.6	27.9
Neither agree nor disagree	34.4	36.8	32.6	35.6	36.7	37.7	35.6
Disagree	14.7	16.7	16.7	16.5	13.4	17.8	15.7
Strongly disagree	3.8	3.5	5.2	4.8	4.5	5.2	4.1

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
53. The Federal Government is not doing enough to find and develop new energy sources.	(955)	(806)	(233)	(186)	(314)	(191)	(2685)
Strongly agree	17.3%	21.2%	20.6%	13.4%	23.2%	27.2%	19.9%
Agree	32.0	29.5	28.3	28.5	28.3	30.9	30.2
Neither agree nor disagree	38.1	35.7	37.8	37.6	34.1	31.4	36.4
Disagree	10.7	12.2	11.2	17.7	13.1	9.4	11.8
Strongly disagree	1.9	1.4	2.1	2.7	1.3	1.0	1.7
54. We are in the present energy situation because we are really running out of oil.	(957)	(805)	(232)	(188)	(314)	(191)	(2687)
Strongly agree	4.0	2.9	5.2	4.8	4.8	3.7	3.9
Agree	18.2	15.5	17.7	16.5	19.1	20.9	17.5
Neither agree nor disagree	38.5	37.1	39.1	37.8	37.9	33.5	37.7
Disagree	30.9	34.8	28.9	32.4	31.5	30.9	32.1
Strongly disagree	8.5	9.7	9.1	8.5	6.7	11.0	8.9
55. Depending too much on oil as an energy source has caused the present energy situation.	(958)	(805)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	11.1	12.3	11.6	13.8	16.6	13.6	12.5
Agree	47.4	46.8	48.5	35.6	42.0	52.9	46.3
Neither agree nor disagree	30.1	26.1	30.5	34.6	26.4	24.1	28.4
Disagree	9.9	12.2	8.6	13.8	13.7	6.8	11.0
Strongly disagree	1.6	2.6	.9	2.1	1.3	2.6	1.9

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
56. Information that we have a right to know about the energy situation is being withheld from us.	(959)	(805)	(233)	(188)	(314)	(191)	(2690)
Strongly agree	14.8%	15.4%	15.9%	13.8%	13.1%	17.8%	15.0%
Agree	34.8	32.8	33.9	28.2	31.8	37.7	33.5
Neither agree nor disagree	39.6	39.0	35.2	41.0	41.1	34.0	38.9
Disagree	9.9	11.7	13.7	13.8	13.1	9.9	11.4
Strongly disagree	.8	1.1	1.3	3.2	1.0	.5	1.1
57. Profiteering by oil and electric companies is largely responsible for the present energy situation.	(958)	(805)	(233)	(187)	(314)	(191)	(2688)
Strongly agree	21.2	22.6	18.5	20.3	18.5	23.6	21.2
Agree	31.8	35.0	33.5	31.6	34.7	37.7	33.7
Neither agree nor disagree	35.7	31.7	35.2	36.4	33.4	26.7	33.6
Disagree	10.2	8.9	10.7	8.6	11.1	11.0	9.9
Strongly disagree	1.0	1.7	2.1	3.2	2.2	1.0	1.6
58. We will have sufficient energy if we develop and adopt more efficient energy saving devices.	(958)	(804)	(233)	(188)	(314)	(191)	(2688)
Strongly agree	12.5	13.8	12.0	12.8	13.7	14.7	13.2
Agree	50.2	51.4	45.1	49.5	48.4	52.9	50.0
Neither agree nor disagree	26.3	23.3	25.3	26.6	26.1	20.9	24.9
Disagree	9.6	10.6	14.6	10.1	11.1	11.0	10.6
Strongly disagree	1.4	1.0	3.0	1.1	.6	.5	.2

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
60. My own personal comfort is more important to me than saving a little heating fuel or electricity.	(958)	(805)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	1.3%	1.9%	2.6%	1.6%	1.3%	1.0%	1.6%
Agree	5.7	9.9	5.6	5.9	8.0	8.9	7.5
Neither agree nor disagree	20.1	28.0	20.6	22.3	21.0	24.1	23.1
Disagree	58.1	51.7	58.4	55.9	71.6	52.4	55.6
Strongly disagree	14.7	8.6	12.9	14.4	12.[illegible]	13.6	12.3
61. The residents of Navy housing in my neighborhood try to conserve energy.	(956)	(803)	(233)	(186)	(313)	(191)	(2682)
Strongly agree	2.1	1.5	4.3	3.2	1.6	1.6	2.1
Agree	20.9	15.1	27.9	23.1	23.3	16.2	19.9
Neither agree nor disagree	53.1	59.3	52.8	55.9	54.0	59.7	55.7
Disagree	17.5	17.3	11.2	13.4	16.6	17.3	16.5
Strongly disagree	6.4	6.8	3.9	4.3	4.5	5.2	5.9
62. There would be enough energy if everyone quit wasting it.	(958)	(805)	(233)	(187)	(313)	(191)	(2687)
Strongly agree	10.4	8.6	8.6	8.0	6.4	7.9	8.9
Agree	37.6	33.8	39.1	39.6	33.9	37.7	36.3
Neither agree nor disagree	36.5	38.4	33.5	34.2	37.4	36.6	36.8
Disagree	14.1	17.1	15.5	16.6	19.5	15.2	16.0
Strongly disagree	1.4	2.1	3.4	1.6	2.9	2.6	2.0

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
63. There is no real shortage of energy.	(959)	(805)	(233)	(188)	(314)	(190)	(2689)
Strongly agree	4.6%	5.6%	3.0%	6.4%	4.5%	5.3%	4.9%
Agree	9.0	13.7	14.2	12.2	8.3	9.5	11.0
Neither agree nor disagree	39.6	38.8	33.9	36.2	30.6	30.5	36.9
Disagree	37.1	33.7	35.6	34.0	40.1	43.2	36.5
Strongly disagree	9.7	8.3	13.3	11.2	16.6	11.6	10.6
64. Wasteful use of energy in the home is to a large extent responsible for the energy situation.	(957)	(805)	(233)	(188)	(314)	(191)	(2688)
Strongly agree	1.9	1.1	1.7	2.1	1.9	2.1	1.7
Agree	18.6	16.0	16.3	22.3	20.7	23.0	18.5
Neither agree nor disagree	35.7	33.8	28.8	29.8	30.3	29.3	33.0
Disagree	35.3	38.6	40.3	34.0	36.6	36.6	36.9
Strongly disagree	8.5	10.4	12.9	11.7	10.5	8.9	9.9
65. Rewarding people who use less energy would really promote energy conservation.	(958)	(805)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	11.7	11.4	9.4	8.5	14.3	14.7	11.7
Agree	41.4	38.1	44.2	42.0	45.9	39.3	41.1
Neither agree nor disagree	26.9	29.3	27.0	28.7	24.2	26.7	27.4
Disagree	16.9	17.3	15.9	18.1	12.4	16.2	16.4
Strongly disagree	3.0	3.9	3.4	2.7	3.2	3.1	3.3

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
66. Those who use too much electricity should have to pay a higher rate for it.	(957)	(806)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	12.3%	11.8%	10.7%	9.6%	10.5%	11.0%	11.5%
Agree	41.9	37.3	39.9	46.3	39.5	35.6	39.9
Neither agree nor disagree	28.3	23.3	26.2	23.9	24.8	24.6	25.7
Disagree	14.3	22.1	18.0	16.0	19.1	23.0	18.3
Strongly disagree	3.1	5.5	5.2	4.3	6.1	5.8	4.6
67. People who use devices that conserve a lot of energy should get a tax break.	(958)	(805)	(233)	(187)	(314)	(190)	(2687)
Strongly agree	16.0	14.3	14.6	15.5	16.6	19.5	15.6
Agree	44.7	42.1	44.2	34.2	43.3	40.5	42.7
Neither agree nor disagree	24.7	24.3	23.6	34.8	24.5	23.2	25.1
Disagree	11.8	15.8	12.4	12.3	12.4	11.6	13.1
Strongly disagree	2.8	3.5	5.2	3.2	3.2	5.3	3.5
68. Overuse of energy by commercial/industrial users is a major cause of the present energy situation.	(957)	(804)	(233)	(187)	(314)	(191)	(2686)
Strongly agree	17.6	17.7	16.7	16.0	14.0	17.3	17.0
Agree	39.4	39.9	37.8	36.4	33.4	36.1	38.3
Neither agree nor disagree	35.0	31.5	34.8	39.6	37.9	34.0	34.5
Disagree	7.0	10.1	8.6	7.0	12.1	11.5	9.0
Strongly disagree	1.0	.9	2.1	1.1	2.5	1.0	1.3

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
69. People who pay for their own utilities use less energy than people who don't.	(959)	(806)	(233)	(187)	(313)	(191)	(2689)
Strongly agree	8.4%	12.3%	11.2%	17.6%	10.9%	12.0%	11.0%
Agree	31.8	30.8	29.6	32.1	39.0	36.1	32.5
Neither agree nor disagree	29.4	24.6	23.2	21.4	25.2	22.5	25.9
Disagree	23.3	26.2	28.8	24.1	20.4	24.1	24.4
Strongly disagree	7.1	6.2	7.3	4.8	4.5	5.2	6.2
70. Technological discoveries will provide all the energy we need long before our present sources run out.	(958)	(805)	(233)	(188)	(314)	(191)	(2689)
Strongly agree	4.8	5.7	6.4	2.1	2.5	4.7	4.8
Agree	16.4	19.4	19.3	21.3	15.6	25.1	18.4
Neither agree nor disagree	58.2	57.0	50.2	54.8	57.3	51.3	56.3
Disagree	16.4	15.9	16.7	17.6	22.6	14.7	17.0
Strongly disagree	4.2	2.0	7.3	4.3	1.9	4.2	3.5

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
71. Listed below are nine topics considered to be of national importance. Which is the <u>FIRST</u> most important?	(955)	(805)	(232)	(185)	(312)	(188)	(2677)
The drug problem	7.7%	7.7%	7.3%	10.3%	7.1%	8.0%	7.8%
Inflation & economy	53.8	64.7	53.0	49.7	60.3	58.5	57.8
Middle East situation	1.9	2.1	4.3	5.4	3.5	3.2	2.7
Crime	14.5	7.8	19.8	18.9	9.0	7.4	12.1
The energy situation	11.2	9.8	9.5	8.6	11.2	16.0	10.8
Unemployment	9.0	7.0	6.0	5.4	7.7	6.4	7.5
Racial equality	1.2	.7	0	1.1	.6	.5	.8
Women's rights	.1	.1	0	0	.3	0	.1
Mass transportation	.6	0	0	.5	.3	0	.3
72. Which is the <u>SECOND</u> most important?	(954)	(805)	(233)	(184)	(312)	(188)	(2676)
The drug problem	9.9	9.2	8.6	12.0	9.6	11.2	9.8
Inflation & economy	18.7	18.3	24.0	19.0	16.3	16.5	18.6
Middle East situation	3.5	3.4	3.9	6.0	4.5	6.4	4.0
Crime	20.9	18.4	20.2	25.5	13.5	14.9	19.1
The energy situation	25.3	30.2	22.3	19.6	34.0	27.7	27.3
Unemployment	19.2	17.9	18.9	14.1	20.2	20.2	18.6
Racial equality	1.3	1.5	1.7	2.2	.6	2.1	1.4
Women's rights	.3	.1	0	.5	0	0	.2
Mass transportation	1.2	1.1	.4	1.1	1.3	1.1	1.1

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
73. Which is the THIRD most important?	(954)	(805)	(232)	(183)	(312)	(188)	(2674)
The drug problem	10.7%	12.9%	14.7%	14.2%	12.2%	5.3%	11.7%
Inflation & economy	11.1	7.6	6.5	15.8	12.5	10.6	10.1
Middle East situation	3.8	6.3	9.1	4.4	7.4	7.4	5.7
Crime	21.3	23.0	21.1	19.1	17.9	20.7	21.2
The energy situation	21.1	23.2	28.4	23.0	21.8	27.1	23.0
Unemployment	23.6	20.2	13.8	16.9	20.8	22.3	20.9
Racial equality	3.0	2.7	3.0	2.2	3.2	2.1	2.8
Women's rights	.9	1.0	.4	0	.3	1.1	.9
Mass transportation	4.5	3.0	3.0	4.4	2.9	3.2	3.6
74. Instructed family members about energy conservation.	(954)	(806)	(230)	(188)	(311)	(191)	(2680)
Have done	87.1	83.3	90.7	85.6	90.4	85.3	86.4
Have not done	10.2	11.5	7.8	9.0	7.1	8.9	9.9
Not applicable	2.7	5.2	1.7	5.3	2.6	5.8	3.8
75. Talked with friends about the energy situation.	(957)	(805)	(232)	(188)	(312)	(191)	(2685)
Have done	73.3	72.2	73.3	74.5	76.9	75.4	74.3
Have not done	22.5	25.6	23.7	22.9	22.1	23.6	23.6
Not applicable	2.2	2.2	3.0	2.7	1.0	1.0	2.1

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
76. Tried to learn more about energy conservation.	(957)	(804)	(232)	(188)	(312)	(191)	(2684)
Have done	73.7%	68.8%	75.9%	73.9%	76.6%	69.1%	72.4%
Have not done	24.2	29.2	22.0	23.4	22.8	28.8	25.6
Not applicable	2.1	2.0	2.2	2.7	.6	2.1	1.9
77. Signed a petition promoting energy conservation.	(955)	(803)	(231)	(187)	(310)	(191)	(2677)
Have done	4.1	1.5	1.3	3.7	2.9	1.6	2.7
Have not done	81.6	83.9	86.6	82.4	81.9	86.4	83.2
Not applicable	14.3	14.6	12.1	13.9	15.2	12.0	14.1
78. Set air conditioning thermostat no lower than 78°F.	(950)	(805)	(230)	(187)	(310)	(191)	(2673)
Have done	11.7	22.1	10.0	12.8	12.6	67.5	18.9
Have not done	5.3	14.9	6.1	9.6	2.9	5.7	9.7
Not applicable	83.1	63.0	83.9	77.5	84.5	6.8	71.4

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
79. Participated in group promoting energy conservation.	(955)	(804)	(232)	(188)	(312)	(191)	(2682)
Have done	5.4%	5.0%	3.9%	5.9%	3.8%	1.6%	4.7%
Have not done	81.6	83.5	81.5	78.7	85.3	91.1	83.0
Not applicable	13.0	11.6	14.7	15.4	10.9	7.3	12.2
80. Set refrigerator thermostat to warmer setting.	(956)	(804)	(232)	(188)	(312)	(191)	(2683)
Have done	55.3	49.0	42.7	42.0	47.4	45.5	49.8
Have not done	41.4	48.5	55.2	53.7	49.7	50.8	47.2
Not applicable	3.2	2.5	2.2	4.3	2.9	3.7	3.0
81. Attended any discussions on energy situation.	(955)	(804)	(232)	(186)	(312)	(191)	(2680)
Have done	17.3	15.4	20.7	21.5	15.7	12.0	16.8
Have not done	77.1	77.6	73.3	72.0	78.5	82.7	77.1
Not applicable	5.7	7.0	6.0	6.5	5.8	5.2	6.1
82. Replaced light bulbs with lower wattage ones.	(957)	(805)	(231)	(187)	(312)	(190)	(2682)
Have done	73.8	70.1	73.6	69.5	71.8	67.9	71.7
Have not done	23.5	29.1	25.1	26.7	26.3	31.1	26.4
Not applicable	2.7	.9	1.3	3.7	1.9	1.1	1.9

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
83. Written to Government about its conservation efforts.	(956)	(805)	(233)	(187)	(310)	(191)	(2682)
Have done	3.0%	3.0%	2.6%	4.3%	4.3%	3.1%	3.2%
Have not done	91.1	91.6	92.7	85.0	91.0	93.2	91.1
Not applicable	5.9	5.5	4.7	10.7	4.8	3.7	5.7
84. Supported energy conservation legislation.	(955)	(802)	(231)	(187)	(311)	(191)	(2677)
Have done	29.2	20.0	24.7	20.3	29.6	22.0	25.0
Have not done	59.7	67.0	64.1	65.2	60.1	68.1	63.3
Not applicable	11.1	13.1	11.1	14.4	10.3	9.9	11.8
85. Written to publication about energy situation.	(956)	(804)	(232)	(188)	(311)	(191)	(2682)
Have done	1.5	2.1	3.9	3.2	1.3	2.1	2.0
Have not done	92.3	91.5	90.9	88.3	93.6	93.2	91.9
Not applicable	6.3	6.3	5.2	8.5	5.1	4.7	6.1
86. Set water heater to medium or low.	(956)	(806)	(232)	(188)	(311)	(191)	(2684)
Have done	68.2	59.7	67.7	56.9	42.1	39.8	59.8
Have not done	27.1	26.6	29.3	34.0	41.8	46.1	30.7
Not applicable	4.7	13.8	3.0	9.0	16.1	14.1	9.6
87. Supported political candidate for his/her stand on energy conservation.	(953)	(805)	(233)	(188)	(311)	(190)	(2680)
Have done	18.9	14.5	17.2	10.6	20.6	16.3	16.9
Have not done	68.6	69.9	69.5	71.3	65.9	73.2	69.3
Not applicable	12.5	15.5	13.3	18.1	13.5	10.5	13.8

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
88. Wash only full loads of laundry.	(957)	(806)	(233)	(188)	(312)	(190)	(2686)
All the time	53.1 %	48.0 %	57.5 %	48.4 %	49.0 %	43.2 %	50.4 %
Most of the time	41.5	45.7	38.6	43.1	45.2	47.4	43.4
Often	3.2	3.1	3.0	2.1	3.5	2.6	3.1
Once in awhile	.9	1.4	0	4.3	0	1.1	1.1
Never	0	.5	0	.5	.3	1.6	.3
Does not apply	1.3	1.4	.9	1.6	1.9	4.2	1.6
89. Have lights on with no one in room.	(956)	(806)	(232)	(188)	(312)	(191)	(2685)
All the time	1.0	.5	2.6	.5	.6	1.6	1.0
Most of the time	4.6	2.4	2.6	1.6	3.2	3.1	3.3
Often	5.9	6.6	6.9	6.9	7.7	5.8	6.4
Once in awhile	68.5	70.6	70.3	61.2	72.4	71.7	69.5
Never	19.9	19.7	17.7	29.8	16.0	17.8	19.7
Does not apply	.1	.2	0	0	0	0	.1
90. Keep heater thermostat 68^{o} or less.	(956)	(805)	(232)	(188)	(312)	(191)	(2684)
All the time	27.3	19.8	19.8	30.3	21.2	16.2	23.1
Most of the time	29.2	29.8	34.5	26.6	27.6	25.7	29.2
Often	13.1	15.9	14.2	6.9	18.3	15.2	14.3
Once in awhile	16.6	21.4	23.7	20.2	20.5	29.3	20.3
Never	5.9	11.2	6.5	5.3	9.6	12.6	8.4
Does not apply	7.9	2.0	1.3	10.6	2.9	1.0	4.7
91. Have window open with heater or air conditioner on.	(957)	(806)	(232)	(188)	(312)	(191)	(2686)
All the time	1.1	.4	1.7	.5	.3	.5	.8
Most of the time	1.9	.6	1.3	1.1	1.0	.5	1.2
Often	1.5	1.4	1.7	1.6	1.6	0	1.4
Once in awhile	20.5	24.8	20.3	17.6	26.3	17.3	22.0
Never	68.3	66.1	69.8	68.6	66.0	81.7	68.5
Does not apply	6.7	6.7	5.2	10.6	4.8	0	6.1

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
92. Use only one T.V. at							
a time.	(956)	(806)	(233)	(188)	(312)	(190)	(2685)
All the time	19.2%	17.6%	18.9%	21.8%	17.6%	24.7%	19.1%
Most of the time	26.4	30.3	27.5	21.8	19.6	16.3	25.8
Often	2.9	5.1	2.6	4.3	3.2	3.2	3.7
Once in awhile	6.5	7.1	4.3	6.9	6.1	6.3	6.4
Never	1.3	1.6	1.3	0	1.3	1.6	1.3
Does not apply	43.7	38.3	45.5	45.2	52.2	47.9	43.6
93. Run dishwasher when							
only partially full.	(955)	(806)	(231)	(188)	(312)	(191)	(2683)
All the time	.6	.7	0	.5	1.0	.5	.6
Most of the time	1.5	.6	.4	1.6	.3	1.6	1.0
Often	1.0	.2	.9	.5	.6	1.6	.7
Once in awhile	15.8	19.1	10.4	13.8	6.1	25.1	15.7
Never	45.4	44.3	26.0	41.5	27.2	55.0	41.7
Does not apply	35.6	35.0	62.3	42.0	64.7	16.2	40.2
94. Heat small items in							
oven or broiler.	(955)	(806)	(233)	(188)	(312)	(191)	(2685)
All the time	.8	1.1	1.3	1.1	0	2.6	1.0
Most of the time	1.8	.9	1.7	1.1	1.9	2.6	1.5
Often	.9	1.7	1,7	.5	2.2	1.6	1.4
Once in awhile	20.9	18.4	23.2	27.7	28.5	27.7	22.2
Never	72.9	75.1	69.5	65.4	63.5	64.9	71.1
Does not apply	2.6	2.9	2.6	4.3	3.8	.5	2.8
95. Turn off heater vents							
in unused rooms.	(957)	(804)	(231)	(186)	(312)	(191)	(2681)
All the time	30.2	31.8	40.3	25.8	33.0	20.9	30.9
Most of the time	15.3	14.8	12.6	10.8	20.8	13.1	15.1
Often	6.0	8.6	7.4	3.8	6.4	9.9	7.0
Once in awhile	5.6	8.1	5.2	5.4	5.4	6.4	6.6
Never	9.1	8.5	11.3	7.0	7.4	17.3	9.3
Does not apply	33.9	28.2	23.4	47.3	26.9	29.3	31.1

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
96. Turn heat down or off when no one is home.	(956)	(805)	(232)	(188)	(312)	(191)	(2684)
All the time	61.7 %	40.7 %	65.9 %	59.0 %	40.7 %	35.1 %	51.3 %
Most of the time	22.6	28.8	21.1	25.0	33.0	35.1	26.6
Often	6.7	12.7	6.5	7.4	9.3	16.8	9.5
Once in awhile	4.7	10.3	2.2	3.2	10.3	6.3	6.8
Never	2.3	6.5	2.2	2.1	5.4	6.3	4.2
Does not apply	2.0	1.0	2.2	3.2	1.3	.5	1.6
97. Have T.V. on with no one in room.	(957)	(806)	(232)	(188)	(312)	(191)	(2686)
All the time	.9	.6	.4	1.1	.6	0	.7
Most of the time	2.4	1.5	3.0	2.1	1.3	1.0	1.9
Often	3.6	4.6	5.2	4.8	2.9	5.8	4.2
Once in awhile	47.4	50.1	48.7	36.2	49.7	53.4	48.3
Never	44.4	42.1	40.5	53.7	43.9	38.2	43.5
Does not apply	1.3	1.1	2.2	2.1	1.6	1.6	1.4
98. Have two T.V.'s on at same time on same program.	(955)	(804)	(231)	(187)	(312)	(191)	(2680)
All the time	.4	.4	.9	0	0	0	.3
Most of the time	1.0	.4	1.7	.5	.6	.5	.8
Often	1.4	.7	0	0	1.0	.5	.9
Once in awhile	8.9	11.3	5.6	8.0	4.5	8.9	8.8
Never	53.7	56.3	51.5	56.7	45.8	48.7	53.2
Does not apply	34.6	30.8	40.3	34.8	48.1	41.4	36.0
99. Remind family members to conserve energy.	(955)	(805)	(232)	(187)	(312)	(191)	(2682)
All the time	33.7	25.0	37.9	31.6	30.1	25.1	30.3
Most of the time	21.6	19.0	15.9	19.8	23.4	13.6	19.8
Often	24.3	29.2	21.6	25.7	23.7	35.6	26.4
Once in awhile	16.3	20.7	22.0	16.6	18.3	17.3	18.5
Never	3.1	4.2	1.7	5.3	3.2	6.3	3.7
Does not apply	.9	1.9	.9	1.1	1.3	2.1	1.3

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
100. Shower or bathe in cooler water.	(955)	(804)	(231)	(187)	(312)	(191)	(2680)
All the time	11.9%	6.6%	10.8%	7.5%	9.3%	6 8%	9.3%
Most of the time	20.4	15.4	13.4	23.0	19.2	14.7	17.9
Often	17.9	15.5	13.9	11.9	11.9	12.0	15.4
Some of the time	28.1	31.7	28.6	26.2	29.2	35.6	29.7
Never	21.4	29.9	32.0	29.4	29.8	29.8	27.0
Does not apply	.3	.9	1.3	0	.6	1.0	.6
101. Take short showers (5 minutes or less).	(956)	(804)	(232)	(187)	(312)	(191)	(2682)
All the time	30.1	27.9	28.0	27.8	27.2	25.7	28.4
Most of the time	33.2	31.1	37.5	33.2	32.4	28.8	32.5
Often	17.1	18.5	13.8	16.6	17.0	19.4	17.3
Some of the time	15.0	14.8	16.4	17.1	15.1	19.9	15.5
Never	3.9	5.8	3.4	3.7	5.8	6.3	4.8
Does not apply	.8	1.9	.9	1.6	2.6	0	1.3
102. Leave oven on after food is out.	(957)	(805)	(232)	(187)	(312)	(191)	(2684)
All the time	.8	.7	1.7	1.6	1.0	.5	.9
Most of the time	1.5	.7	1.7	.5	1.0	.5	1.1
Often	.7	.5	.4	1.1	.3	.5	.6
Some of the time	19.5	23.1	25.0	16.0	19.6	22.0	21.0
Never	77.2	74.3	71.1	80.2	78.2	75.9	76.0
Does not apply	.2	.6	0	.5	0	.5	.3
103. Wash hair while in shower.	(957)	(805)	(232)	(187)	(312)	(191)	(2684)
All the time	52.0	56.5	53.0	56.7	63.1	62.3	55.8
Most of the time	22.8	21.7	19.4	20.3	19.2	23.0	21.6
Often	10.0	9.9	9.5	8.6	5.8	7.3	9.2
Some of the time	10.6	7.0	15.9	8.6	5.8	5.2	8.9
Never	3.9	3.5	1.7	4.8	4.5	1.6	3.5
Does not apply	.7	1.4	.4	1.1	1.6	.5	1.0

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
104. Have curtains open during day when air conditioner is on.	(954)	(805)	(232)	(187)	(311)	(191)	(2680)
All the time	.6%	1.6%	1.3%	.5%	0%	8.4%	1.5%
Most of the time	.7	3.9	.9	.5	0	12.0	2.4
Often	1.6	5.7	1.3	.5	1.3	11.0	3.4
Some of the time	2.7	13.4	2.6	3.7	2.9	35.1	8.3
Never	11.5	18.4	8.2	9.1	7.4	26.2	13.7
Does not apply	82.8	57.0	85.8	85.6	88.4	7.3	70.8
105. Open refrigerator just once to get all items.	(956)	(805)	(232)	(187)	(312)	(191)	(2683)
All the time	10.1	5.8	9.1	9.1	7.1	4.2	7.9
Most of the time	38.2	30.7	29.7	38.0	37.8	26.7	34.3
Often	23.1	24.8	22.8	21.4	23.7	26.2	23.8
Some of the time	20.5	26.3	26.7	20.3	20.2	29.8	23.4
Never	7.5	11.2	11.2	10.7	10.9	13.1	10.0
Does not apply	.5	1.1	.4	.5	.3	0	.6
106. Use clothes washer when partially full.	(955)	(806)	(230)	(186)	(312)	(191)	(2680)
All the time	.7	.9	.4	1.6	1.3	.5	.9
Most of the time	2.6	1.6	3.5	4.3	1.3	1.0	2.2
Often	2.8	2.6	1.3	3.2	3.2	1.0	2.6
Some of the time	42.5	47.3	45.7	41.4	49.4	52.9	45.7
Never	48.4	45.3	47.8	46.2	41.0	38.2	45.7
Does not apply	2.9	2.4	1.3	3.2	3.8	6.3	3.0
107. Lower heater thermostat at bedtime.	(955)	(806)	(232)	(187)	(312)	(191)	(2683)
All the time	42.8	40.4	49.1	49.7	39.7	28.8	41.8
Most of the time	25.0	20.3	25.0	15.0	21.5	25.7	22.5
Often	9.1	11.7	7.8	8.6	11.5	14.1	10.4
Some of the time	9.9	13.5	9.5	11.8	11.9	18.8	12.0
Never	7.9	13.5	6.0	8.0	14.7	12.6	10.5
Does not apply	5.2	.5	2.6	7.0	.6	0	2.8

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
108. Keep windows closed when heat or air conditioner is on.	(956)	(805)	(233)	(187)	(312)	(191)	(2684)
All the time	67.2%	67.7%	67.8%	67.9%	64.4%	80.1%	68.0%
Most of the time	25.7	25.8	24.5	19.8	27.6	17.8	24.9
Often	3.0	3.5	3.4	2.7	2.2	1.0	2.9
Some of the time	1.0	.7	.7	1.6	2.6	.5	1.1
Never	.4	.4	0	.5	.6	0	.4
Does not apply	2.6	1.9	3.4	7.5	2.6	.5	2.6
109. Preheat oven for roasts or casseroles.	(957)	(803)	(232)	(187)	(312)	(191)	(2682)
All the time	9.6	13.0	10.3	12.3	9.0	9.4	10.8
Most of the time	15.6	17.9	19.8	16.0	12.5	19.4	16.6
Often	10.3	12.6	9.1	12.3	13.5	7.9	11.2
Some of the time	30.5	30.9	27.6	31.6	30.4	39.8	31.1
Never	33.4	24.4	32.3	26.7	34.3	23.0	29.5
Does not apply	.5	1.2	.9	1.1	.3	.5	.8
110. Wash dishes in running water rather than filling sink.	(956)	(805)	(233)	(186)	(312)	(191)	(2683)
All the time	4.0	4.6	3.4	4.3	5.1	6.3	4.4
Most of the time	6.3	6.0	7.7	7.0	7.1	4.2	6.3
Often	6.0	8.0	2.6	8.1	6.1	7.9	6.6
Some of the time	28.7	27.3	26.6	29.6	22.1	28.8	27.4
Never	49.0	47.7	53.6	41.4	54.2	45.0	48.8
Does not apply	6.2	6.5	6.0	9.7	5.4	7.9	6.5

Item		Location					
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
111. Taking showers instead of baths.	(956)	(806)	(233)	(188)	(312)	(191)	(2686)
All the time	45.5%	44.8%	48.9%	42.6%	43.6%	49.7%	45.5%
Most of the time	34.1	31.9	30.5	28.7	31.1	30.9	32.2
Often	9.2	10.4	6.0	11.2	11.9	9.4	9.8
Some of the time	9.5	9.6	12.0	13.3	10.9	9.4	10.2
Never	1.6	2.6	2.6	3.7	2.6	.5	2.2
Does not apply	.1	.7	0	.5	0	0	.3
112. Leave electric blanket on after getting up.	(953)	(803)	(232)	(187)	(312)	(191)	(2678)
All the time	.1	.4	.4	.5	0	0	.2
Most of the time	.9	.4	.4	.5	.6	.5	.6
Often	.9	1.0	.9	0	.3	0	.7
Some of the time	1.9	4.2	3.9	3.7	5.8	4.7	3.5
Never	21.3	24.4	25.9	23.0	21.8	32.5	23.6
Does not apply	74.8	69.6	68.5	72.2	71.5	62.3	71.2
113. Turn oven on to heat kitchen.	(956)	(805)	(231)	(187)	(312)	(190)	(2681)
All the time	.6	.5	1.3	0	.6	.5	.6
Most of the time	1.5	.7	1.3	.5	.3	0	.9
Often	.4	.6	0	1.1	0	0	.4
Some of the time	3.1	5.2	2.2	4.8	2.9	2.1	3.7
Never	90.9	90.2	91.8	88.2	92.9	96.8	91.2
Does not apply	3.5	2.7	3.5	5.3	3.2	.5	3.1

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
114. Reduce number lights on at same time.	(954)	(805)	(232)	(188)	(312)	(190)	(2681)
All the time	36.5%	26.8%	37.5%	34.6%	36.2%	32.1%	33.2%
Most of the time	43.3	44.6	43.5	37.8	44.2	47.4	43.7
Often	15.5	18.1	12.9	18.6	13.5	15.3	16.0
Some of the time	3.6	8.4	5.2	6.4	5.8	3.2	5.6
Never	.6	1.4	.9	2.7	.3	1.6	1.0
Does not apply	.5	.6	0	0	0	.5	.4
115. Use clothes dryer when not full.	(952)	(806)	(233)	(188)	(312)	(190)	(2681)
All the time	.4	.7	1.3	1.6	.6	.5	.7
Most of the time	2.3	1.2	1.7	2.1	1.3	1.6	1.8
Often	1.7	2.7	2.6	3.2	3.2	2.6	2.4
Some of the time	43.8	49.6	51.1	47.9	54.2	51.6	48.2
Never	40.0	41.9	39.9	38.3	34.9	27.9	39.0
Does not apply	11.8	3.7	3.4	6.9	5.8	15.8	7.9
116. Use cooking time to see if food is done rather than looking.	(955)	(806)	(233)	(188)	(312)	(190)	(2684)
All the time	35.9	26.4	30.9	31.9	37.8	24.7	31.8
Most of the time	45.5	51.5	44.6	44.1	42.6	50.5	47.2
Often	7.7	9.9	9.9	7.4	9.0	12.6	9.1
Some of the time	7.3	8.1	9.9	12.8	9.0	6.8	8.3
Never	2.7	3.1	3.9	2.1	1.3	4.7	2.9
Does not apply	.7	1.0	.9	1.6	.3	.5	.8

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
117. Set stove flame to match pot size.	(954)	(805)	(231)	(187)	(312)	(191)	(2680)
All the time	64.7%	64.8%	47.6%	61.5%	30.4%	60.7%	58.8%
Most of the time	25.3	26.6	19.9	24.6	14.1	27.7	24.0
Often	4.8	5.0	4.8	5.3	4.8	2.6	4.7
Some of the time	1.3	1.6	3.0	3.7	.3	5.2	1.9
Never	2.6	1.5	1.7	3.2	1.6	2.6	2.1
Does not apply	1.4	.5	22.9	1.6	48.7	1.0	8.5
118. Leave refrigerator door open unnecessarily.	(956)	(806)	(233)	(188)	(311)	(191)	(2685)
All the time	.9	.7	.9	0	1.6	0	.8
Most of the time	2.1	1.0	1.7	1.1	.6	2.1	1.5
Often	2.2	1.6	2.1	1.1	1.9	2.6	1.9
Some of the time	24.4	27.7	27.0	26.6	26.7	32.5	26.6
Never	70.3	68.6	67.4	70.2	68.8	62.8	68.8
Does not apply	.1	.4	.9	1.1	.3	0	.3
119. Wash clothes in cold water.	(954)	(805)	(233)	(187)	(312)	(191)	(2682)
All the time	10.4	9.4	12.0	7.5	11.9	7.9	10.0
Most of the time	19.0	23.7	18.0	16.0	25.0	20.9	21.0
Often	24.1	30.6	21.9	26.2	25.0	29.3	26.5
Some of the time	37.5	29.1	37.3	40.1	31.1	31.9	34.0
Never	7.7	6.5	10.7	9.1	4.8	6.3	7.2
Does not apply	1.4	.7	0	1.1	2.2	3.7	1.3

AD-A081 057 OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE (--ETC F/G 13/1
FAMILY HOUSING METERING TEST. A TEST PROGRAM TO DETERMINE THE F--ETC(U)
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Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
Would you be willing to:							
120. Read informational literature about the energy situation?	(953)	(789)	(232)	(186)	(312)	(190)	(2662)
% Yes	95.6%	95.9%	96.6%	96.2%	96.8%	95.3%	95.9%
121. Support a political candidate for his/her strong support of energy conservation?	(928)	(777)	(228)	(184)	(305)	(186)	(2608)
% Yes	62.1	59.8	61.8	60.9	65.2	67.7	62.1
122. Instruct and remind your family about energy conservation?	(956)	(799)	(232)	(187)	(313)	(191)	(2678)
% Yes	98.4	96.7	99.6	98.9	98.7	99.5	98.2
123. Participate in an experiment in which you would receive money or gifts for conserving energy?	(946)	(792)	(230)	(183)	(310)	(189)	(2650)
% Yes	76.0	74.9	75.2	71.6	77.7	76.2	75.5
124. Support energy conservation legislation even though *it might* raise your taxes slightly?	(937)	(791)	(228)	(181)	(305)	(188)	(2630)
% Yes	49.6	45.0	47.4	54.1	49.2	52.1	48.5

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
125. Shut off your household heating except on cold days (below 65 degrees F)?	(956)	(799)	(232)	(184)	(311)	(189)	(2671)
% Yes	82.8%	72.8%	79.3%	86.4%	66.6%	67.7%	76.8%
126. Shut off your water heater?	(947)	(792)	(230)	(183)	(312)	(189)	(2653)
% Yes	9.2	11.2	11.3	12.0	7.7	18.5	10.7
127. Replace light bulbs with ones of lower wattage?	(955)	(800)	(231)	(185)	(312)	(189)	(2672)
% Yes	89.9	88.0	89.2	82.2	91.7	92.6	89.1
128. Be part of an experiment in which the names of energy overusers are printed in the local newspaper?	(946)	(792)	(230)	(184)	(310)	(189)	(2651)
% Yes	38.6	34.2	37.0	33.2	38.7	34.4	36.5
129. Wash clothes in cold water most of the time?	(955)	(800)	(230)	(185)	(311)	(189)	(2670)
% Yes	77.6	80.1	70.9	78.9	84.6	81.0	78.9
130. Turn down heater thermostat to 65 degrees F?	(949)	(798)	(231)	(185)	(312)	(189)	(2664)
% Yes	79.5	59.6	73.2	80.5	67.0	59.8	70.2

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
Have you noticed the following problems in your housing?							
131. Doors that do not close tightly?	(957)	(802)	(230)	(185)	(313)	(191)	(2678)
% Yes	53.7%	74.1%	57.4%	49.2%	55.9%	69.6%	61.2%
132. Windows that do not close thghtly?	(956)	(803)	(231)	(186)	(313)	(191)	(2680)
% Yes	46.0	56.5	51.9	39.8	44.1	56.0	49.7
133. Cracks in floors, walls, ceiling, etc?	(957)	(803)	(229)	(186)	(313)	(191)	(2679)
% Yes	26.5	50.1	27.9	26.9	23.6	26.7	33.4
134. Refrigerator which does not have tight door seal?	(956)	(804)	(228)	(186)	(313)	(191)	(2678)
	18.3	15.2	14.5	14.5	14.1	13.6	15.9
135. Hot water faucets that drip?	(955)	(803)	(230)	(187)	(313)	(190)	(2678)
% Yes	17.7	25.0	33.5	23.5	24.6	45.8	24.5
136. Drapes or curtains missing?	(953)	(799)	(229)	(186)	(313)	(191)	(2671)
% Yes	17.7	17.4	30.1	26.9	29.1	30.4	21.6
137. Cracked or broken windows?	(955)	(802)	(230)	(185)	(313)	(191)	(2676)
	15.9	13.6	23.0	17.8	32.9	9.9	17.5

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
138. Rooms (other than kitchen or bathroom) without carpeting?	(950)	(802)	(229)	(186)	(312)	(191)	(2670)
% Yes	83.2%	77.1%	79.0%	75.3%	77.6%	83.2%	79.8%
139. Other problems?	(487)	(458)	(122)	(91)	(179)	(92)	(1429)
% Yes	73.7	81.4	73.0	70.3	77.1	75.0	76.4
140. It takes energy in some form to generate electricity.	(956)	(805)	(233)	(186)	(310)	(191)	(2681)
% correct (true)	98.0	98.1	95.3	97.8	96.5	98.4	97.7
141. Electricity can be economically stored in large amounts for use when we need it.	(948)	(798)	(232)	(180)	(309)	(189)	(2656)
% correct (false)	70.7	72.7	73.3	63.9	70.9	67.2	70.8
142. Most of our natural gas is produced artificially.	(939)	(796)	(229)	(182)	(307)	(189)	(2642)
% correct (false)	83.7	84.9	85.2	84.1	87.0	87.3	84.9
143. Fluorescent light bulbs can use less energy and yet produce more light than incandescent bulbs.	(951)	(803)	(228)	(184)	(309)	(191)	(2666)
% correct (true)	90.7	86.4	90.4	91.8	89.3	90.6	89.3
144. The United States has 40% of the world's oil reserves.	(933)	(796)	(226)	(179)	(305)	(188)	(2627)
% correct (false)	63.5	63.9	[illegible]	53.6	63.3	62.8	[illegible]

Item	Location						
	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
145. A nearly full freezer generally uses less energy than ones that are not so full. % correct (true)	(951) 81.7%	(803) 81.8%	(232) 76.7%	(184) 73.9%	(313) 83.4%	(191) 78.0%	(2674) 80.7%
146. The same natural process which results in oil and coal also produces natural gas. % correct (true)	(934) 74.9	(786) 79.0	(226) 80.1	(178) 75.3	(307) 81.4	(189) 72.5	(2620) 77.2
147. A 150 watt light bulb produces twice the light of a 75 watt bulb but uses three times more electricity. % correct (false)	(945) 33.0	(791) 32.4	(229) 28.4	(180) 36.1	(311) 30.9	(190) 27.9	(2646) 32.0
148. The United States imports more than 25% of its oil. % correct (true)	(937) 89.4	(794) 91.7	(229) 93.9	(179) 91.1	(307) 90.6	(190) 95.8	(2636) 91.2
149. Putting extra soap in with your clothes wash can increase the amount of electricity that the machine uses. % correct (true)	(944) 36.0	(800) 39.0	(232) 39.7	(183) 30.1	(310) 38.4	(191) 34.0	(2660) 37.0

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
150. The amount of frost in your freezer does not affect the amount of energy it uses.	(953)	(802)	(232)	(186)	(311)	(191)	(2675)
% correct (false)	90.5%	91.6%	87.5%	89.2%	89.7%	88.0%	90.2%
151. When we generate electricity, we produce more energy than we expend to run the generators.	(923)	(783)	(227)	(180)	(301)	(189)	(2603)
% correct (false)	40.1	37.0	37.9	37.2	37.9	40.2	38.5
152. At what setting do you keep your heating thermostat when the house is occupied during the day?	(937)	(804)	(231)	(182)	(312)	(191)	(2657)
65^o or less	46.4	13.8	44.2	47.8	15.1	16.8	30.6
66^o	3.2	3.9	2.6	3.8	4.2	3.1	3.5
67^o	6.6	5.0	7.4	6.0	5.4	2.6	5.7
68^o	25.8	32.7	25.5	23.1	31.7	29.8	28.7
69^o	3.2	4.5	4.8	4.9	7.7	2.6	4.3
70^o	11.8	27.6	10.4	10.4	25.6	30.9	19.4
71^o	.9	3.5	.9	.5	3.5	2.1	2.0
72^o	1.2	5.3	3.9	2.2	5.4	6.3	3.6
73^o or more	.9	3.7	.4	1.1	1.3	5.8	2.1
Mean temperature:	66.9°	68.6°	67.0°	66.8°	68.4°	68.7°	67.7°

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
153. At what setting do you keep your heating thermostat after you go to bed at night?	(937)	(804)	(231)	(184)	(312)	(191)	(2659)
65° or less	55.1%	44.0%	53.2%	67.4%	42.9%	36.1%	49.6%
66°	4.5	7.3	6.1	4.9	7.7	7.3	6.1
67°	5.3	4.9	3.5	3.3	3.5	4.7	4.6
68°	20.3	19.9	22.1	14.7	23.7	24.1	20.6
69°	2.8	2.4	3.0	1.6	5.8	1.6	2.9
70°	6.5	13.6	8.7	5.4	12.2	16.8	10.9
71°	.6	1.6	0	0	1.6	.5	.9
72°	1.2	3.6	3.0	1.6	1.9	3.7	2.4
73° or more	1.7	2.7	.4	1.1	.6	5.2	2.0
Mean temperature:	66.6°	67.1°	66.6°	66.1°	67.0°	67.5°	66.8°
154. At what setting do you keep your cooling system when it is being used during the day?	(942)	(798)	(231)	(183)	(310)	(191)	(2655)
No cooling system	96.2	74.3	98.7	96.7	97.4	1.0	83.2
68°	.8	3.0	.4	0	1.0	5.8	1.8
70°	1.0	3.5	0	0	.3	9.9	2.1
72°	.2	3.3	0	0	.6	12.0	2.0
74°	.2	4.8	0	.5	0	12.6	2.4
76°	.5	4.9	.4	1.1	0	19.4	3.2
78°	1.0	4.6	.4	1.1	.6	28.3	4.0
80°	0	1.3	0	.5	0	8.9	1.1
82° or more	.1	.4	0	0	0	2.1	.3

Item	San Diego	Great Lakes	Pt. Mugu	Port Hueneme	Whidbey Is.	Whiting Field	Total
	Location						
155. At what setting do you keep your cooling system after you go to bed at night?	(942)	(796)	(230)	(183)	(310)	(191)	(2652)
No cooling system	96.2%	74.9%	98.3%	96.7%	97.4%	1.6%	83.3%
68° or less	1.0	3.1	.9	0	1.0	9.4	2.1
70°	1.0	3.4	0	0	0	10.5	2.1
72°	.1	2.5	0	0	.6	6.8	1.4
74°	.1	3.3	0	.5	0	7.3	1.6
76°	.5	3.5	.4	1.1	0	16.2	2.5
78°	.6	4.8	0	1.1	.6	26.7	3.7
80°	.2	2.8	.4	.5	.3	14.1	2.0
82° or more	.3	1.8	0	0	0	7.3	1.2
156. Do you own a T.V. that has an instant "on" feature?	(950)	(798)	(230)	(185)	(312)	(190)	(2665)
No	49.4	48.0	47.8	47.0	53.2	54.7	49.5
Yes, just one	43.1	42.2	45.2	47.0	40.1	42.1	42.9
Yes, more than one	7.6	9.8	7.0	5.9	6.7	3.2	7.7

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Naval Facilities Engineering Command (Code 082) (5)

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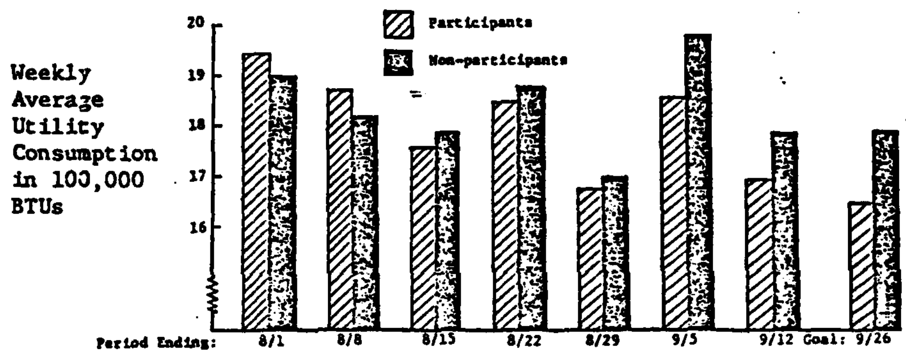
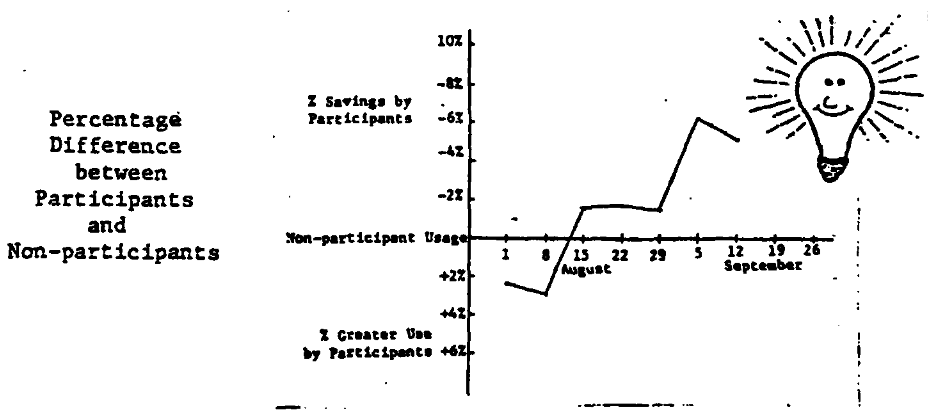
September 17, 1979
No. 4

Energy Conservation Results

There's good news from the third two-week period of the energy conservation study (which preceded the hurricane)! Although the overall average utility consumption was slightly higher, probably due to the weather, the difference between participants and non-participants was the largest yet achieved (see graph below).



Results show that participants have turned their initial handicap into better than a 5% advantage, an improvement of 7.5% (8.5% the previous week)! The percentage difference for each week is shown in the figure below.



This notable improvement demonstrates that applying the energy conservation tips can make a difference, and the more of us who apply them the bigger the difference will be. Let's concentrate on helping our children become aware of how their actions can affect our energy consumption and what they can do to "save a fossil by conserving energy".

Our 10% goal is definitely within reach now, so keep up the good work!

Detective Program

By now our young detectives are actively observing their household for energy thieves. If they see any thieves, they should be "turned in" to headquarters (parents) immediately. By the end of the week your utility use may be improved, and everyone should be aware that their behavior can make a difference in household consumption. The watt you save may be your own (to use in the future).

All the energy detectives who completed their log sheets are eligible for 6 self-sticking, fluorescent-colored energy slogans. Just hand in the parent's certification slip to me next time I pass by.

ENERGY EFFICIENCY THROUGHOUT THE HOME

Over the past several weeks the Tips in the Kil-A-Watt have concerned efficient use of large energy consumers around the house (air conditioners, water heaters, refrigerators, freezer, clothes washer and dryer, and dishwasher). That's because those are where the real conservation payoff is found. Today, I have some more tips, but I'm also including a listing of the relative energy consumption of various household appliances. Much of this information will come as good news to you.

Energy Consumption of Household Appliances

Major Consumers	Uses Per Year	KWH/YR
Washer (not including water heating)	364	120
Dryer	364	1180
Freezer (16 cu. ft.; manual def.)	Continuous	1188
(16.5 cu. ft.; auto. def.)	Continuous	1824
Refrigerator/Freezer (17 cu. ft.; auto. def.)	Continuous	2256
Television (Color; solid state)	365 (6 hrs per day)	420
Lighting	Daily	1140-2640
Dishwasher (not including water heating)	364	360
Minor Consumers		
Baby Food Warmer	1092	22
Blender	293	0.9
Can Opener	1000	0.3
Clock	Continuous	22
Blanket	250	150
Corn Popper	30	5
Fry Pan	180	100
Griddle	100	46
Hair Dryer - Hand Held	250	25
Iron	52	60
Knife	90	0.8
Mixer - Hand	150	1
Roaster	12	60
Rotisserie	26	73
Shaver	365	0.5
Slow Cooker	26	35
Toaster	700	39
Toaster-Oven	780	93
Toothbrush	Continuous	10
Warming Tray	26	7

Loosely quoting one utility's conservation advice:

> "Everybody's favorite target seems to be the electric toothbrush. A lot of people pat themselves on the back for hanging it up. But a continuous charge toothbrush costs less than 5 cents per month to operate—no matter how many times you brush each day. Eliminating that is hardly a savings you can sink you teeth into.
>
> The electric shaver is another conservation victim. Yet you can take a five-minute electric shave every day for the next 7 years and 4 months for a dime. It would cost you more to run hot water and shave with a straight edge.
>
> In the kitchen, things like toasters, crockpots, frypans and broiler ovens take a lot of heat. Yet they can actually be big energy savers. You can cook with all of them—sometimes whole meals—for a fraction of the energy you'd use with your range or oven.
>
> A microwave oven seems like a space age luxury. But with small quantities of food it can cut cooking energy costs by 75%, because it's on for such a short time. Electric can openers and popcorn makers are good guys too.
>
> Almost every appliance can be a good guy if used properly. Which means that the biggest energy thief of all may be you. Remember, it's not the energy you need that's bad, it's the energy you waste."

Let me add that what's wasted costs us twice, because we have to replace it for the use it should have gone to in the first place.

TIPS FOR HOMEWIDE ENERGY EFFICIENCY

1. TURN LIGHTS OFF WHEN LEAVING A ROOM--A 100-watt bulb burning half a day requires 1/2 pint of oil at the electric generating plant.

2. USE COLD WATER FOR DISPOSALS--This saves the energy required to heat the water, and aids in getting rid of grease.

3. FIX THE DRIPS--One drop of hot water a second is nearly 200 gallons a month. That's energy down the drain!

4. WATCH LIGHTING WATTAGE--One large bulb is better than several small ones. It takes six 25-watt bulbs to get light equal to a 100-watt bulb and the six 25-watt bulbs use 50 percent more electricity. Correct wattage is important for safety and detailed work but you can save energy by using lower wattage bulbs for decorative and accent lighting.

5. KEEP LIGHT FIXTURES CLEAN--Clean, dust free light fixtures maximize lighting and use energy efficiently.

6. TAKE SHORT SHOWERS--A 5-minute shower saves 1/3 of the water used in a tub bath. Assuming half hot water, just one shower substituted for one bath per day would save about 2,000 gallons of hot water in a year.

7. USE EXHAUST FANS SPARINGLY--Kitchen, bath, and other venilating fans can blow away an entire houseful of warmed or cooled air in just 1 hour.

8. USE A PRESSURE COOKER--It cooks food faster (in about one-third the time), and thus saves energy.

Janice W. McNair

THE CORRY KIL-A-WATT

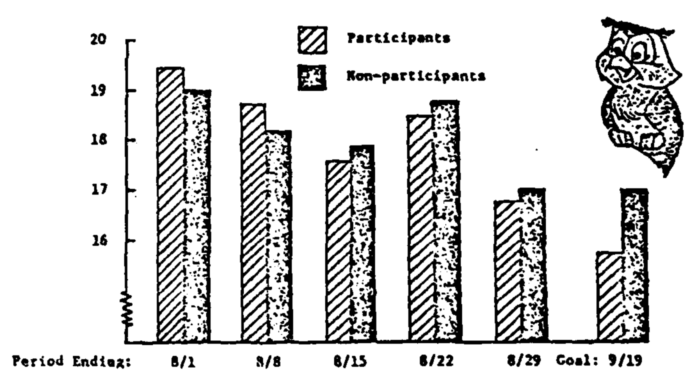
September 4, 1979
Volume No. 3

ENERGY CONSERVATION RESULTS

The results of the second two-week period of the energy conservation study at Corry Housing indicate we're making progress, although it's slightly slower than we had anticipated. Corry energy conservation participants had the lowest utility consumption so far, a very encouraging finding. Because of milder weather conditions, non-participants also reduced their consumption, a factor which did not permit us to achieve our goal of a 10% energy savings. Although we have not yet reached our goal, the results do seem to show that some people are finding the energy conservation tips helpful, and that people in their families are pulling together to "use energy wisely." The chart below shows the weekly average utility consumption for participants and non-participants.

UTILITY CONSUMPTION OF PARTICIPANTS COMPARED TO NON-PARTICIPANTS

Weekly Average Utility Consumption in 100,000 BTUs



I want to commend everyone for their efforts; I expect that conscientious application of the energy conservation tips by every family will lead to our achieving the goal of a 10% savings. Please note the additional kitchen tips on the back. Keep the air conditioning tips in mind, because they have the greatest impact on utility consumption: Thermostat settings--78° or higher; minimize heat generated inside--close drapes, cook and wash dishes during cooler hours of the day; maximize efficiency--change fileter and use exhaust fans when appropriate. Let's shoot for the 10% savings and watch our watts!

CORRY SPECIAL EVENTS

ENERGY CONSERVATION POSTER CONTEST. It's time to let the young people direct some of their own energy toward a little creative expression! Get out the paper, scissors, glue, marking pens, and anything else that seems appropriate, because we're having a poster contest. The theme of the contest is "Energy Conservation in the Home." The rules are simple:

1. Anyone 18 years of age and younger is eligible to participate.
2. Posters must be at least 8 x 10 inches.
3. Artist's name, age, and quarters number must be printed on the lower right corner (front).
4. Posters must be turned in to the NAS Pensacola Housing Office or to Janice McNair by 4p.m. on September 10th.
5. A maximum of 3 entries per person is allowed.

Posters will be judged on originality, appropriateness and style. Ribbons will be given for 1st through 5th places and honorable mention in each age division. There will be an exhibition of all posters and an awards cermony. Time, dates, and location of the exhibition and awards ceremony will be forthcoming. Let's see how we can use our energy to save energy!

KITCHEN AND LAUNDRY TIPS

If you want to save energy in the kitchen, the place to start is with the appliances you use the most and which require the most power. These are the refrigerator/freezer, dishwasher, washer and dryer, and oven/range. We've looked at two of the big appliances already, the refrigerator/freezer and the dishwasher. This week our main focus will be the remaining big consumers, the washer and dryer and oven/range. Can openers, electric knives, blenders and other small appliances account for only a fraction of one percent of all the electricity used in the home. So, whether or not you consider them to be frills, enjoy the small appliances and place your conservation efforts toward the big energy consumers.

WASHER/DRYER

1. FILL WASHER AND DRYER COMPLETELY--Fill your washer and dryer completely, but don't overload them. If they have small-load attachments or special low water levels, use these for smaller loads. It takes nearly as much energy to wash and dry a small load as it does a full load.

2. SELECT CORRECT WASH TIME--Select a wash time to match load and soil levels. Regular clothes need only a 10-15 minute washing cycle.

3. SELECT CORRECT WASH WATER TEMPERATURE--Use warm or cold water whenever possible. Cold or warm water can be used to wash permanent press articles, washable woolens, and lightly soiled articles. In addition to energy savings, cold water is more effective than hot water in removing lint collected on garments. Use a cold water rinse.

4. USE CORRECT AMOUNT OF DETERGENT--Follow the instructions on the detergent box. Oversudsing makes your machine work harder and uses more energy.

5. KEEP FILTERS CLEAN--Clean the lint filter on your dryer after each use. Lint impedes air flow in the dryer, lengthens drying time and uses more energy.

6. DRY CLOTHES IN CONSECUTIVE LOADS--Occasional drying uses more energy to warm the dryer up to the desired temperature each time you begin.

7. USE "FLUFF" OR "AIR ONLY" SETTING--If your dryer has one, "fluff" and "air only" settings can be used for permanent press fabrics, saving your clothing and watts.

8. USE WASHER AND DRYER IN THE EARLY MORNING OR LATE EVENING HOURS--The heat generated by your laundry equipment will add to the already warm temperature of your summer home.

OVEN/RANGE

1. PLAN COMPLETE OVEN MEALS--A complete meal can be cooked for little more energy than an individual item.

2. DON'T PEEK--Opening an oven door unnecessarily can result in the loss of as much as 20% of the heat.

3. COVER POTS AND PANS--Covered pots and pans retain the heat better, allowing for lower cooking temperatures and faster cooking times. Also, use a pot or pan that is the same size or larger than the burner. A pot too small for the unit will allow extra heat to escape into the kitchen, a situation especially undesirable during the warm summer months.

4. USE THE OVEN--For foods requiring long cooking periods, such as stews, use your oven instead of the range top. Surface units stay on the whole time they are in use; the oven is on for only part of each hour it's used. The rest of the time it "coasts" because its insulation holds heat in. Another advantage is that less heat is dissipated into the air when the oven is used instead of the range top, reducing heat buildup in a warm summer home.

5. USE A MODERATE FLAME--When cooking with the rangetop burner, use moderate flame settings to conserve gas.

6. USE A MICROWAVE OVEN AND PORTABLE COOKING EQUIPMENT--For small or specialized jobs, microwave ovens and portable cooking equipment, such as broilers, skillets, coffee pots, and toasters, generally use less energy than your oven or range top would for the same time.

7. USE THE EXHAUST FAN--The exhaust fan can remove hot moist air from the kitchen, allowing your air conditioner to efficiently maintain a comfortable household temperature.

Janice W. McNair
Phone: 452-4412